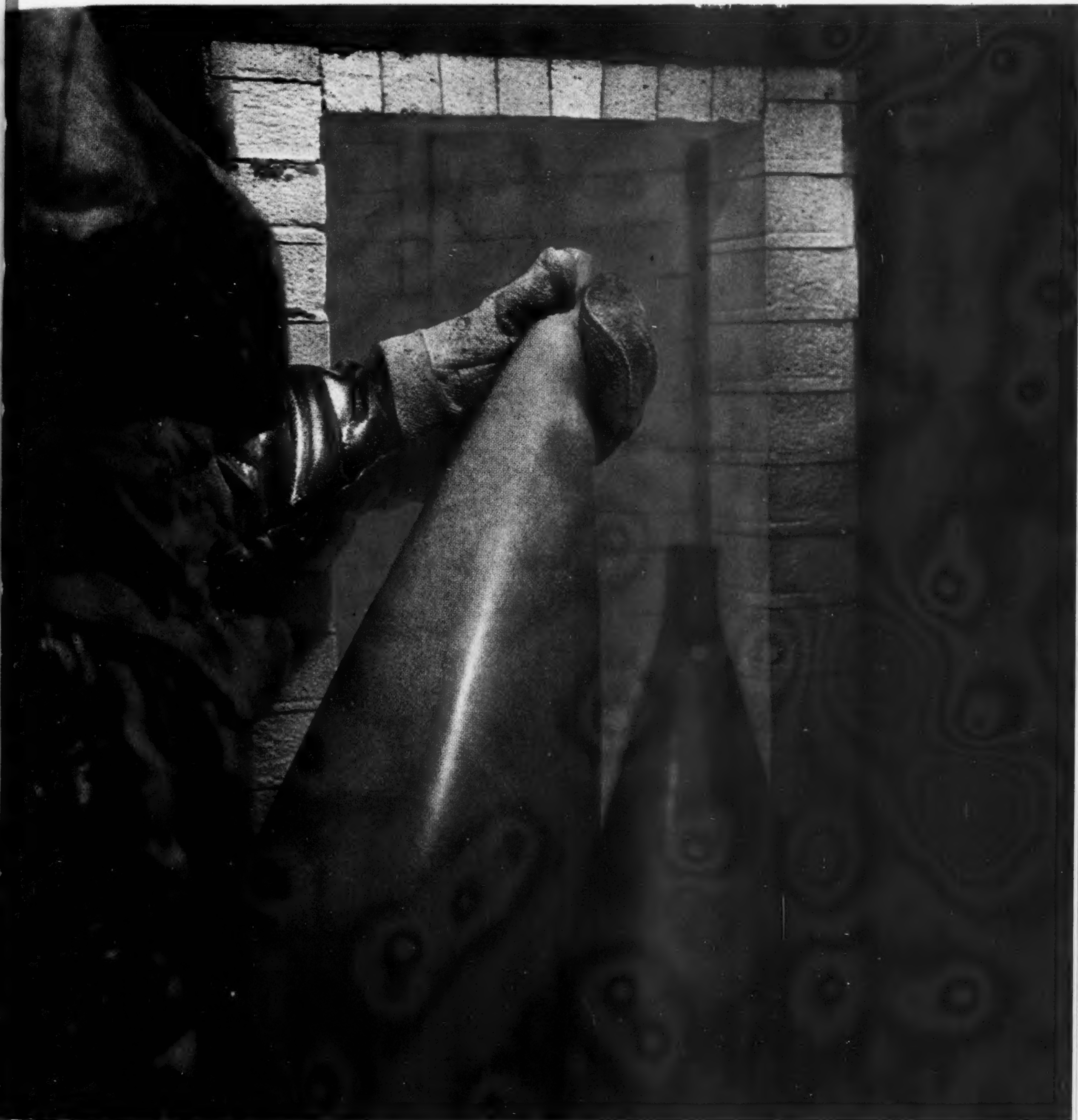
Astronautics

A PUBLICATION OF THE AMERICAN ROCKET SOCIETY

SEPTEMBER 1957



When Will Rockets Go Commercial? . . . . *G. Edward Pendray*

10 Years of Missile Progress . . . . *Adm. John H. Sides*

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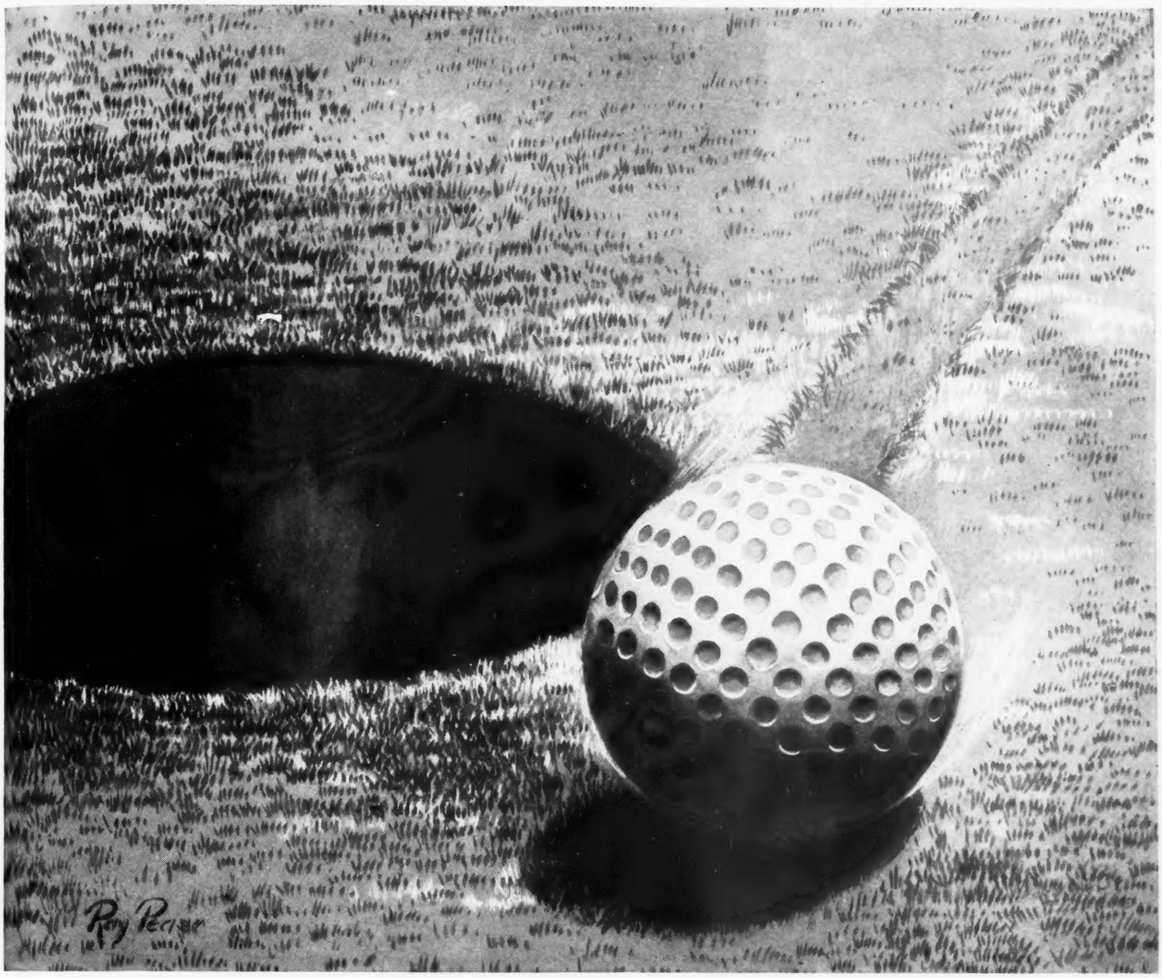

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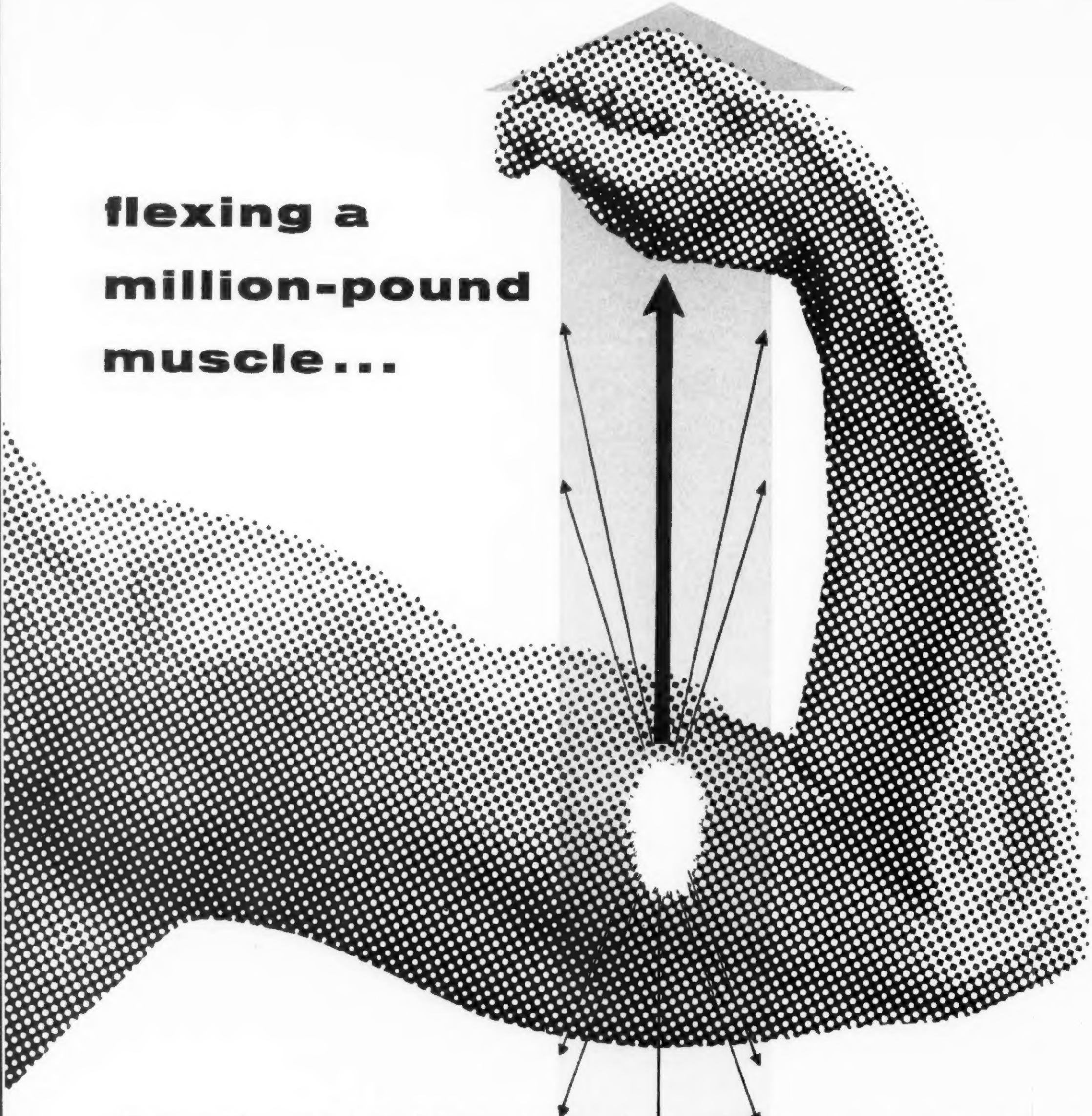

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Astronautics

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FEATURES

ASTRONAUTICS REPORT

NEWS

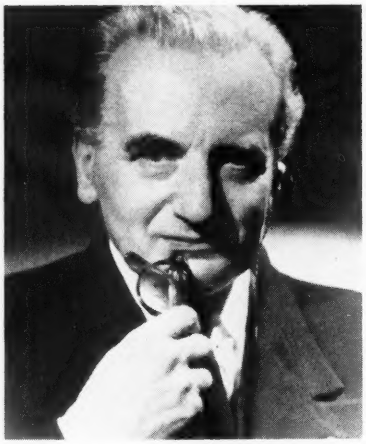
DEPARTMENTS

Woods Hole Conference Maps Long-Range AF Plans

IN A large white house on Church Street in Woods Hole, Mass., during the past few months, much of the aeronautical and astronautical history of the United States for the coming 10 to 20 years has been effectively written.

More than 100 of this country's outstanding scientists in those fields, as well as in disciplines ranging from nuclear physics to social behavior, have met in supersecret sessions at Woods Hole since June 24. They have quietly formulated the technical pylons that the Air Force will steer by for the next decade or two.

Garnered from 26 universities, 20 industrial firms and eight government research agencies, the experts sifted technical reports prepared by a dozen committees made up of top AF personnel. Under the direction of famed flight authority Theodore van Kármán, they reviewed, evaluated and integrated the AF findings, then projected them into 1965 and 1975 for a long-range technical estimate of where U. S. air power will be by then.



Theodore von Kármán heads AF planning group.

NAS Sponsored Meetings

The National Academy of Sciences sponsored the meetings under a contract from the Air Research and Development Command. Amount of the contract has not been disclosed.

Participating in the conference along with Dr. von Kármán, who heads NATO's Advisory Group for Aeronautical Research and Development, were such well-known civilian scientists as Detlov Bronk, NAS president and president of Rockefeller Institute; Francis H. Clauser, The Johns Hopkins University; Charles S. Draper, MIT; Hugh L. Dryden, director of the National Advisory Committee for Aeronautics; George Gamow, University of Colorado; J. H. Holloman, General Electric; Joseph Kaplan, UCLA professor and head of the U. S. National Committee for the International Geophysical Year; Edwin M. McMillan, Nobel laureate from the University of California; Clark B. Millikan of Cal Tech; Athelstan F. Spilhaus of the University of Minnesota; H. Guyford Stever, MIT; Edward Teller, renowned hydrogen bomb authority of the University of California; J. R. Townsend, Sandia Corp.; and many others.

The military contingent at the conference was led by Col. Adolph P. Gagge of the Air Force Office of Scientific Research.

Taking off from today's most advanced weapon systems on the power of their personal knowledge and experience, the scientists will develop the most promising courses to be followed, then carry them through to basic ideas about the second and third generations of today's systems. And from these ideas undoubtedly will come prognostications on systems beyond the horizon, perhaps in such unexplored fields as interplanetary travel, manned and unmanned satellites, and the host of related directions in which man's ingenuity and curiosity will take him.

Of more pragmatic importance, perhaps, are the tangible savings in facilities, manpower, time and money that the AF expects to realize as a result of the study. By being aware of trends well in advance, the long-range planners expect to be able to slash the lead time off some weapon systems while at the same time eliminating wasteful "crash" programs. In the over-all picture, the AF hopes to make future weapon development more efficient and more evenly distributed over a given time-period than at present.

The first significant attempt at such across-the-board AF planning was the outcome of a similar conference held at the end of World War II, also under Dr. von Kármán's direction. It was convened at the request of the Air Corps chief, Gen. H. H. Arnold. Its purpose was to evaluate the present and predict the future; more specifically, to determine where we were in relation to the other powers of the world and where we probably would be in the next 10 to 20 years.

About a year after the group set to work in 1944, Dr. von Kármán's Scientific Advisory Group published the now-classic 11-volume work titled "Toward New Horizons." Each volume dealt with an area considered vital to the AF. Ten years afterwards, its forecasts compared so well with fact that the AF decided to repeat the study. Only one additional area, nuclear ordnance, had to be considered to insure coverage of the entire research and development spectrum.

Those topics, the same ones that were batted around at the Woods Hole sessions, covered missiles and space vehicles, propulsion, aircraft, electronics, materials and the aerosciences. Subdivided under aerosciences were six more categories: Guidance and control, geophysics, aeromedicine and biosciences, psychology and social sciences, nuclear air ordnance, and non-nuclear air ordnance.

But while ARDC followed the basic outline of topics, it started from scratch in 1955 when it ordered a new study across the R&D board. A committee for each of the basic subjects was formed. Included on the committees were representatives of ARDC and OSR, plus ARDC's best scientists.

Heading the committees were Maj. Gen. D. N. Yates, missiles; Maj. Gen. Troup Miller, propulsion; Brig. Gen. Ralph Wassell, aircraft; Maj. Gen. Thomas L. Bryan, electronics; Brig. Gen. Marvin C. Demler, materials; and Maj. Gen. Edward P. Mechling, aerosciences.

ARDC Will Review Results

Less than a year after their 1955 assignments, the committees reported back. These reports were turned over to the NAS for distribution in connection with the Woods Hole gathering. The results of the conference will be formalized and presented to ARDC before the NAS contract runs out next year.

Then the long-range planners at ARDC will really go to work, translating the findings into the everyday language of facilities, manpower, management, dollars. Under Brig. Gen. J. W. Carpenter III, section chief, and with the aid of Lt. Col. S. E. Ernst, project officer for the Woods Hole gathering, ARDC personnel will determine the monumental requirements needed to implement all the findings of the report.

Every two to three years after that, the report will be brought up to date by repeating the cycle of study programs. In this way, it is hoped that scientific breakthroughs can be incorporated into the long-range plan that was effectively formulated at Woods Hole.

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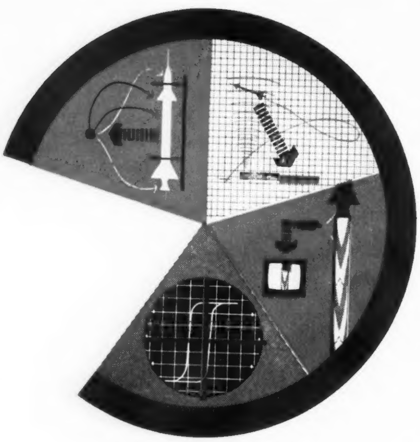

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at press time

Up-to-the-minute news about the rocket, guided missile and jet propulsion fields

ICBM

• Russia claimed it successfully tested an intercontinental ballistic missile late last month. Woven with disarmament propaganda, the Soviet announcement said the "multi-stage" weapon reached "unprecedented" altitude before landing "in the target area" after covering a "huge distance in a brief time."

IRBM

• A three-man committee to resolve the Army-Air Force competition over the intermediate-range ballistic missile has been appointed by departing Defense Secretary Wilson. It includes DOD missile czar William M. Holaday, AF Ballistic Missile Division Chief Schriever, and Army Ballistic Missile Agency Chief Medaris. The committee will first come up with a plan for evaluating the missiles, probably before Wilson leaves, then implement the plan. This will involve further tests of both weapons. A directive to the committee called for the choice to be made "at the earliest practical date."

• Consensus in the Pentagon is that the basic choice will probably be the more conservatively designed AF Thor, although guidance features may come from Jupiter. Engines of both missiles have been identical since inception of the projects; auto-pilots are also very similar. Agreement on basic issues between Schriever and Medaris is reported to be remarkably good in view of the bitter rivalry that has marked development work.

• Jupiter advocates continue to plump for their bird. They note that it has tested better, on the basis of time in flight and distances covered, than Thor. On the other hand, Jupiter may not yet have established a final configuration, each of the test vehicles having been different. The 3000-mile Jupiter-C, used to test a nose cone, was reportedly boosted by a cluster of solid rockets to achieve longer flight time.

DEFENSE DEPT.

• Neil H. McElroy, president of Procter & Gamble, was confirmed by the Senate as new Secretary of Defense. Charles E. Wilson is expected to leave office and multiple headaches in October, giving McElroy at least a month to get acquainted before setting off on his own. The new Defense Secretary is an unknown quantity to Pentagon missile brass.

AIR FORCE

• Bell Aircraft's Rascal, air-to-surface liquid-fueled missile with supersonic capabilities over a 100-mile range, has been ordered into operation by the AF. The B-47 bomber will reportedly use the weapon to extend its effective range and at the same time facilitate its penetration of heavily defended enemy air space.

• Holloman Space Biologist Maj. David G. Simons rose to a record-breaking height of more than 100,000 ft over Minnesota late last month. He stayed aloft 32 hours, riding in an aluminum gondola below a 200-ft-diam balloon. For his feat, Dr. Simons was awarded the Distinguished Flying Cross.

ARMY

• Nike-Hercules batteries defending major U. S. cities will store atomic warheads by next February.

• Sergeant, Army's first big solid-fueled missile, will make its bow in November. A possible replacement for the liquid-fueled Corporal, the surface-to-surface weapon is in the 100-mile-range class.

ARMY

• Army has need for a better battlefield missile than the 200-mile liquid-fueled Redstone now in operation and is presently developing one, Defense Secretary Wilson revealed. The service's need for a 600–800 mile weapon has yet to be determined, despite the current feasibility studies on such a medium-range ballistic missile, he added.

• First tactical Lacrosse anti-strong-point missile has come off The Martin Co. lines in Orlando, Fla. Interim production facilities are being used pending completion of a $7-million plant there.

IGY

• Final plans for rocket and satellite firings will be coordinated at a Sept. 30 conference in Washington. Details of Soviet plans to put up one or more pole-orbiting spheres were expected at the meeting, according to Belgian professor Marcel Nicolet, Secretary-General of the IGY.

• Meanwhile, some data on the Russian satellite have been released. Soviet Science Academician Yevgeny Federov, who is responsible for Russian rocket and satellite programs, said their sphere would rise 200, 300 or 500 km, leaving the three-stage rocket at 29,000 km per hour, roughly the same as planned for the U. S. satellite. However, another academician, electronics expert Vladimir Kotelnikov, has reportedly expressed doubts that Russia has the hardware to put a sphere in orbit.

• The American Museum-Hayden Planetarium in New York will hold an Earth, Air and Space Symposium on the International Geophysical Year on Sept. 12. Seven of the eight scheduled speakers are members of the U. S. National Committee for the IGY. Among them are Joseph Kaplan, USNC-IGY chairman, and Richard W. Porter, who heads the IGY technical panel on the earth satellite program.

SECURITY

• More information released to the public on missile test firings at Cape Canaveral would be "foolhardy," ruled Assistant Defense Secretary for Public Affairs Murray Snyder. Snyder denied it was impossible to conceal data about weapons launched in public view, as they are, for the most part, from Patrick AFB. Press reports of such firings are rumor and guesswork, he contended, hence do not threaten the country's security. More official data might, he added. The Air Force, through Congress, was expected to take the fight over Snyder's head, however.

ECONOMY

• Excepting only ballistic missiles, the Defense Department has ordered a drastic reduction in military spending. At the same time, funds were shifted around to give the Air Force $300 million more for fiscal 1958, making its total authorization almost $18 billion, however.

• The Air Force was told to slash its rate of spending for this year by nearly $1.38 billion. To meet this, it planned to cut civilian payrolls by five per cent, effecting savings of $8 million a month. It called on private aircraft companies to do likewise. If effected, the plan would idle an estimated 90,000 persons. Again, ballistic missile-makers were exempted.

• Army and Navy spending was also affected, the Army's portion of defense funds dropping from $9.17 billion to $8.95 billion, and the Navy's rising slightly to $10.4 billion.

FOREIGN

• Many examples of Britain's growing stock of missiles will be on display at the annual Farnsborough air show this month. Included are such newcomers as Vickers-Armstrong's Red Dean, an air-to-air weapon suited to the needs of all-weather fighters, and the Bristol Borzoi, an advanced research vehicle.

• Two Russian guided missile facilities have been built overlooking Peter the Great Bay near Vladivostok, Japanese investigators report. The 115-mile-wide bay has been closed to foreign ships since late July.

MISSILE METAL MACHINING

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people in the news

APPOINTMENTS

Aerojet-General Corp. has announced a number of major organizational changes, including the establishment of five new divisions. As a result of these changes, **W. L. Rogers** has been named manager and **G. G. Whipple** assistant manager, Azusa operations; **E. E. Nelson,** formerly manager, Solid Rocket Plant, Sacramento, becomes resident manager, administration, Sacramento plants; **R. D. Geckler** succeeds Nelson as Solid Rocket Plant manager; and **W. C. House,** formerly chief engineer, Liquid Engine Div., becomes manager of the division, which supervises such projects as the Vanguard second-stage powerplant and Aerobee-Hi development.


Rogers **Whipple**


Nelson **Geckler**

Newly established divisions, with their respective managers, are Structural Plastics, **E. L. Rucks;** Explosive Ordnance, **G. C. Throner;** Chemistry, **D. L. Armstrong;** Turbo-Machinery, **Gordon Banerian,** all located at Azusa; and the Nuclear Coordinating Div., located at San Ramon, Calif. All these divisions will report directly to the office of the vice-president, engineering, **C. C. Ross.**

In addition, the office of customer relations has been extended to cover field service and will remain under **W. L. Gore** as director.

Arthur C. Ruge and **Robert P. Lathrop** have been appointed director and manager, respectively, of research


Ruge **Lathrop**

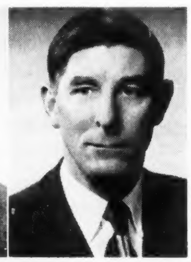
and development, Electronics and Instrumentation Div., Baldwin-Lima-Hamilton Corp. Dr. Ruge originated the SR-4 strain gage in 1938 while a member of the MIT faculty.

Capt. Grayson Merrill, Navy missile expert, has been named director of engineering for the Guided Missiles Div., Fairchild Engine and Airplane Corp. Prior to his retirement from the Navy in July, Capt. Merrill was technical director of the Navy's Polaris program.

Callery Chemical Co. has named **Robert G. Schmidt** project manager for its new $4-million boron specialty chemicals plant at Lawrence, Kan.

Continued expansion in research activities at Allied Research Associates has resulted in the appointments of **Daniel J. Fink** as chief engineer and **Claude W. Brenner** as chief project engineer of the Aeronautical and Mechanical Engineering Div.

Arthur J. Warner has been appointed director of research for Mycalex Corp. of America and associated companies. He will superintend the company's expanded materials and product development program.

Schmidt **Warner**

John L. McLucas has been appointed president of Haller, Raymond & Brown, Inc., replacing **Robert V. Higdon** who moves up to vice-president for long-range planning of the parent company, Topp Industries, Inc. McLucas had been vice-president and technical director of Topp Industries since 1956 and represented the president's office in technical matters.

Standard Pressed Steel has advanced **Bennett D. Jones,** manager of product development, to the new post of technical director, Aircraft Div. Jones will coordinate research and product development activities with the needs of the aircraft and missile industries.

R. J. Seltzer has been appointed vice-president in charge of operations for Gladden Products Corp.

Richard W. Millar, managing partner of William R. Staats & Co., has been appointed to the board of directors of Turco Products, Inc.


Seltzer **Peterson**

W. Jerome Peterson has been appointed chief design engineer for Chandler-Evans Div., Pratt & Whitney Co.

Richard B. Hubbard, former president of the ERCO Div. of ACF Industries Inc., has been elected vice-president and assistant to the president of Pacific Airmotive Corp.

Robert Main, responsible for the design and development of the guidance system of the Navy's Regulus II missile and for airborne bombing control radar at Stavid Engineering Inc., has joined Hamilton Standard Div. of United Aircraft Corp. as manager of the electronics department. **George I. Willis** was named assistant manager. A major reorganization of the division's engineering department has resulted in a number of promotions: **Donald G. Richards,** to the new post of chief of technical staff; **Walter C. Shaw,** to chief of preliminary design; **James D. Evers,** to design engineer; **Joseph T. Fleming** and **George Savchitz,** to design project engineers; **Donald P. Ramaker** and **Charles B. Brahm,** to senior project engineers; **James S. Sims,** to preliminary design engineer; and **Richard A. Allen** and **John W. Rogers,** to project engineers.

Louis R. Ripley has moved from the president's seat at Heli Coil Corp.


Main **Brewer**

to the same post at Waltham Precision Instrument Corp. **Max A. Geller,** president of Weiss & Geller, becomes chairman of the finance committee of Waltham and **Harold Nohe,** formerly treasurer of Heli Coil, is treasurer.

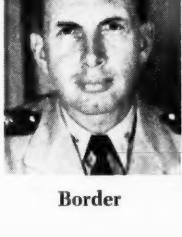
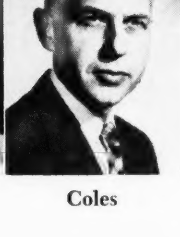
Olin Mathieson Chemical Corp. has named **G. Richard Lott** manager of the customer relations department, research and development, of its high energy fuels organization. Its Explosive Div. has appointed **Leonard Brewer** project director for rocket engines in the research and development department of its solid propellants organization.

Milton M. Kanter has been named to the newly created post of assistant to the vice-president and secretary of Ford Instrument Co. Div. of Sperry Rand Corp.

Two top executive vice-presidents have been promoted by General Precision Laboratory, Inc. **Raymond L. Garman** has been elected to the new post of chairman of the board; **James W. Murray** becomes president and chief executive officer. Garman will continue as technical director in charge of research and development, and Murray as general manager.

Comdr. Robert Lee Border, USN, has been named engineering officer at the U. S. Naval Air Rocket Test Station, Lake Denmark, Dover, N. J. He succeeds **Comdr. Page Goldbeck** who shifted to Rensselaer Polytechnic Institute, Troy, N. Y.

Donald K. Coles is the new head of the solid state laboratory, Farnsworth Electronics Co. Div. of International Telephone and Telegraph. He was previously at Westinghouse Research Laboratories, where he pioneered in infrared and microwave spectroscopy.

Border **Coles**

Herbert H. Rogge, former executive vice-president, has succeeded **Samuel M. Felton,** retired, as president of American Car and Foundry Div. of ACF Industries, Inc. Felton will remain with the company as an advisor.

Chrysler Corporation's Defense Operations Div. has upped **Chester C. Utz,** chief engineer for defense engineering, to executive engineer.

At International Business Machines Corp., **Robert W. Hubner,** former director of recruitment, has been upped to executive assistant to **L. H. LaMotte,** executive vice-president and general manager of the company's Data Processing Div. **William R. Graves** takes over as director of recruitment and personnel services, and **William B. McWhirter** as general manager of the Supplies Div.

Sterling C. Spielman was made director of engineering of Philco Corp.'s Government and Industrial Div. He will head all design and engineering activities, and will be assisted by **Frank D. Peltier,** named director of engineering planning.

Republic Aviation Corp. has announced the appointment of **Brig. Gen. C. Pratt Brown,** USAF (Ret.), as assistant to the president for special assignments. Gen. Brown's offices will be in Washington, D. C.

Laurance S. Rockefeller, president and director of Rockefeller Brothers, Inc., and **Robert W. Purcell,** business adviser to the Rockefeller brothers, have been elected to the Vitro Corp. of America board of directors. Rockefeller also is a director of Rockefeller Center, Eastern Airlines, Inc., Olin Mathieson Chemical Corp., and International Nickel Co. of Canada, Ltd.

John Love is now president of newly formed Laminair, Inc., Gardena, Calif. **F. R. Schwend** is vice-president and **Stanley Harkins** sales manager. Laminair will specialize in aircraft and missile structural and radio frequency glass fiber laminates.

William A. Cooke has been named president of the new Telemetering Corp. of America, Los Angeles, Calif. **Hugh F. Pruss** becomes vice-president and chief engineer. The company will concentrate on the instrumentation and automation fields, with emphasis on telemetry as it applies to the development of airborne vehicles.

Gladyn H. Putt has joined Lockheed Aircraft Corp. as executive assistant to vice-president **L. Eugene Root,** who is also general manager of its Missile Systems Div. Previously, Putt was with the Rand Corp. At the Missile Systems Div., **Stephen J. Jatras** has been promoted to the new post of assistant to the director of the research and development branch, Palo Alto, Calif. **Russell L. Reiserer** succeeds Jatras as manager of research and development coordination.

Appointment of **Ben W. Badenoch** as general manager of the recently created Aero Hydraulics Div. has been announced by Vickers, Inc. Badenoch was formerly aircraft product sales manager.

Wallace G. Wade has been made laboratory chief at Janco Corp.


Badenoch **Wade**

National Science Foundation has named **Paul E. Klopsteg** associate director for research. He had been president of the Central Scientific Co., and professor of applied science and director of research, Northwestern Technological Institute.

John M. Linforth, former vice-president, Goodyear Tire and Rubber Co., has been made chairman of Hexcel Products, Inc., and named to its management committee.

HONORS

Jack Kaufman, International Glass Corp. executive vice-president and co-founder of the corporation's Lewis and Kaufman Electronic Div., has been appointed an executive reservist in telecommunications by Gordon Gray, director of ODM.


Linforth **Cannon**

Clifford Cannon, E. B. Wiggins Oil Tool Co., Inc., has been chosen committee chairman of the Self Sealing Connector Design Sub-Committee, SAE Committee AE-3. The committee strives toward development of fluid line connector and seal designs for modern airplanes.

How High Is Up? Operation Far Side May Find Out

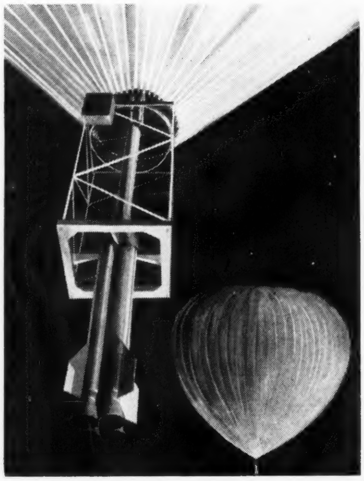
NO ONE is saying just how far Air Force Operation Far Side is expected to go when it takes to the air shortly, other than "to a height never before achieved." Chances are, however, that this latest high altitude experiment will carry a fair number of miles into space, possibly into the thousands.

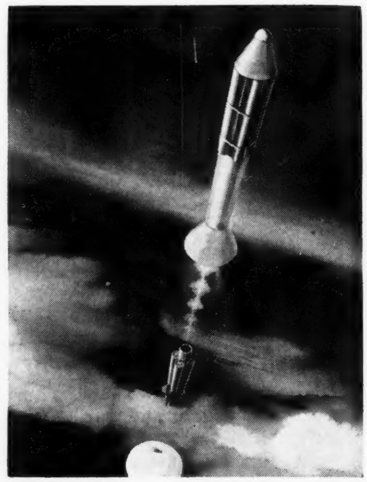
To begin with, the 1900-lb research vehicle will get a free balloon ride to 100,000 ft before it is even fired. Then, ten solid propellant rockets will take it from there, pushing the four-stage vehicle and its small, $3^1/_2$ lb instrument package to a velocity of over 17,000 mph.

In the first stage, there will be four Thiokol Recruit rockets similar to those used in the second and third stages of the X-17 re-entry test vehicle. When these burn out, the first stage will drop off. In the second stage, there will be another Recruit rocket engine. The third stage will consist of four Grand Central Arrow II rocket motors, and the fourth stage, of a single Arrow II.

The balloon that will carry the unit on the first leg of its trip into space was developed by General Mills. Fully inflated with helium, it is more than 200 ft in diam, has a volume of 3,750,000 cu ft, and weighs approximately 1500 lb. In a recent test, the balloon, made of polyethylene, carried a dummy vehicle and associated launching platform weighing more than 2300 lb to more than 104,000 ft.

All in all, this will be an imposing array of transportation for such a small payload. The heights that the researchers hope to attain, of course, make this apparent imbalance necessary. The plan is to investigate atmospheric and space phenomena "at extremely high altitudes." Specifically, the small instrument package will measure cosmic rays, the earth's magnetic field, and the related effect of geomagnetic storms on these measurements. A miniaturized radio transmitter in the package will send the data to the ground, where it will be recorded and later analyzed.





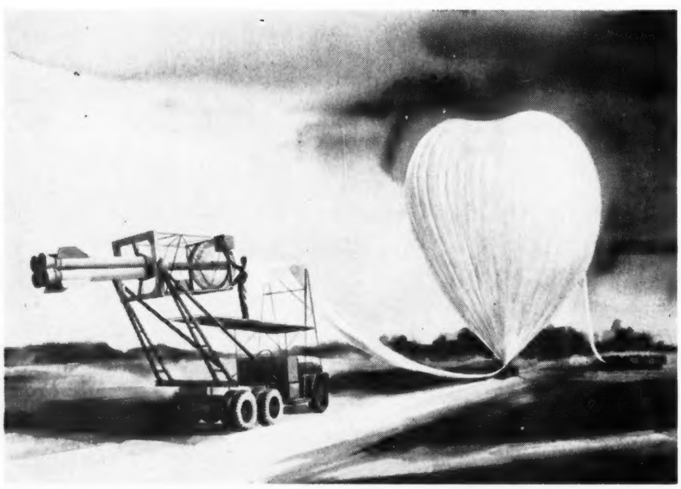
At 100,000 ft, the Far Side research rocket will be fired vertically through the apex of the balloon as shown in these two illustrations.

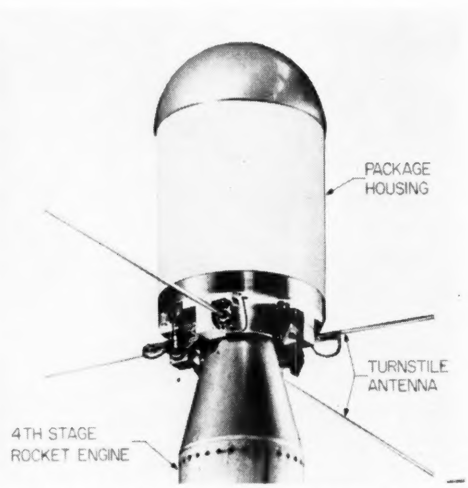
Behind this experiment is the Air Force Office of Scientific Research. Morton Alperin, director of advanced studies for AFOSR, will be project monitor for Far Side. And Ford Motor Co.'s Aeronutronic Systems, with Herbert L. Karsch as project officer, has been designated prime contractor for the project, with responsibility for designing, fabricating and firing the extreme altitude vehicle, and developing the necessary instrumentation.

Perhaps the single most noteworthy feature of Far Side is that the vehicle uses only off-the-shelf hardware, with the attendant advantage of very low cost in comparison with Vanguard.

The historic experiment was scheduled for this month, with the journey into space originating from a sandy atoll in mid-Pacific. Five more Far Side shots are planned for late fall.

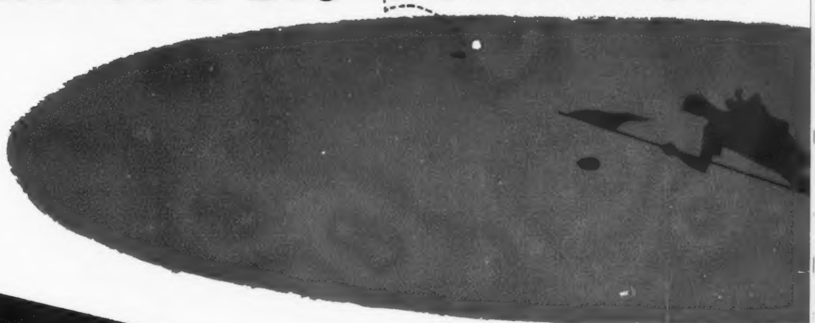
Once the current project is completed, present plans call for further experiments at even higher altitudes. Where will it stop? In the words of one high altitude researcher: "When someone finds out how high is up."





Far Side researchers will use this 3,750,000-cu-ft, helium-filled balloon plus 10 solid propellant rockets to place $3^1/_2$ lb instrument package (right) in space.

"APPROACH" makes a BIG DIFFERENCE!



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London Plays Host to Rocket-Satellite Symposium

ROCKET scientists from United States, Russia, Great Britain and other European nations met in London for three days in late July to discuss the problems and peaceful uses of high altitude rockets and space satellites. The international symposium was sponsored jointly by the Royal Aeronautical Society, the British Interplanetary Society and the College of Aeronautics.

More than 150 delegates were told by an American space medicine specialist that lack of sensation, not the lack of gravity, would probably upset the space traveler more than anything else. The speaker was Lt. Col. James P. Henry of the European office of the Air Research and Development Command, stationed in Brussels, Belgium.

Col. Henry, designer of the AF's T-1 high altitude suit, explained that sudden accelerations, cosmic radiation and the known biological hazards of cramped quarters can be taken in stride by man, or so it would appear if rocket-carried animals offer any criterion. However the effects of weightlessness and sensory deprivation are relatively undetermined.

Important experiments recently carried out in Canada dealt with this sensory deprivation, Henry noted. They showed that men suffered from serious hallucinations similar to those induced by drugs when they were seated for any length of time in a dark, completely silent room; wearing frosted goggles while being kept in a well-lit room in which a hum obscured all other sound; staying submerged in breathing apparatus for long periods; and lying on a bed but cut off from sensations of touch by gloves and cardboard cuffs on the hands and feet.

"In all cases," Henry reported, "the men . . . became easily angered or depressed. They lose their power to think systematically and productively, they are subject to 'blank' periods when they 'simply cannot think.' Simple tests such as arithmetic or handwriting show gross impairment.

"Subjectively," he continued, "the most alarming symptom was the appearance of hallucinations. Starting with simple dots of light, lines and geometric patterns, as time wore on they reported seeing more and more complex waking dreams."

Space travelers, the colonel concluded, must continue to get reassuring sensations and stimuli during flight; otherwise they might suffer mental breakdowns within a few hours of take-off. Care must be taken to keep their minds constantly occupied during the trip.

In other sessions, B. M. Petrov, a member of the Soviet Academy of Sciences, said his country planned to fire 125 high altitude research rockets during the International Geophysical Year. These include 25 from the Arctic, 70 from mid-Russia and 30 from the Antarctic.

British engineers revealed that their fast, efficient, solid-fueled Skylarks cost about $5000 each. Although of limited range, the high altitude 25-ft rocket can reach 100 miles up with perfect burning of its Bristol-made Raven engine. Raven develops 11,500 lb of thrust in 30 sec of flight.

The United States uses Aerobee's and Aerobee-Hi's for probing the upper atmosphere. These liquid-fueled rockets develop about 20,000 lb of thrust and cost close to $35,000 each. Top altitude recorded by one of these Aerojet-General vehicles is 193 miles.

Reported on Re-entry Problems

William F. Hilton, chief aerodynamicist of the Armstrong Whitworth Aeroplane Co., and credited with originating the phrase "sound barrier," reported on some re-entry problems expected to be encountered. He suggested an inverted saucer shape for a vehicle to withstand aerodynamic heating as it slows down by means of diminishing ellipses around the earth.

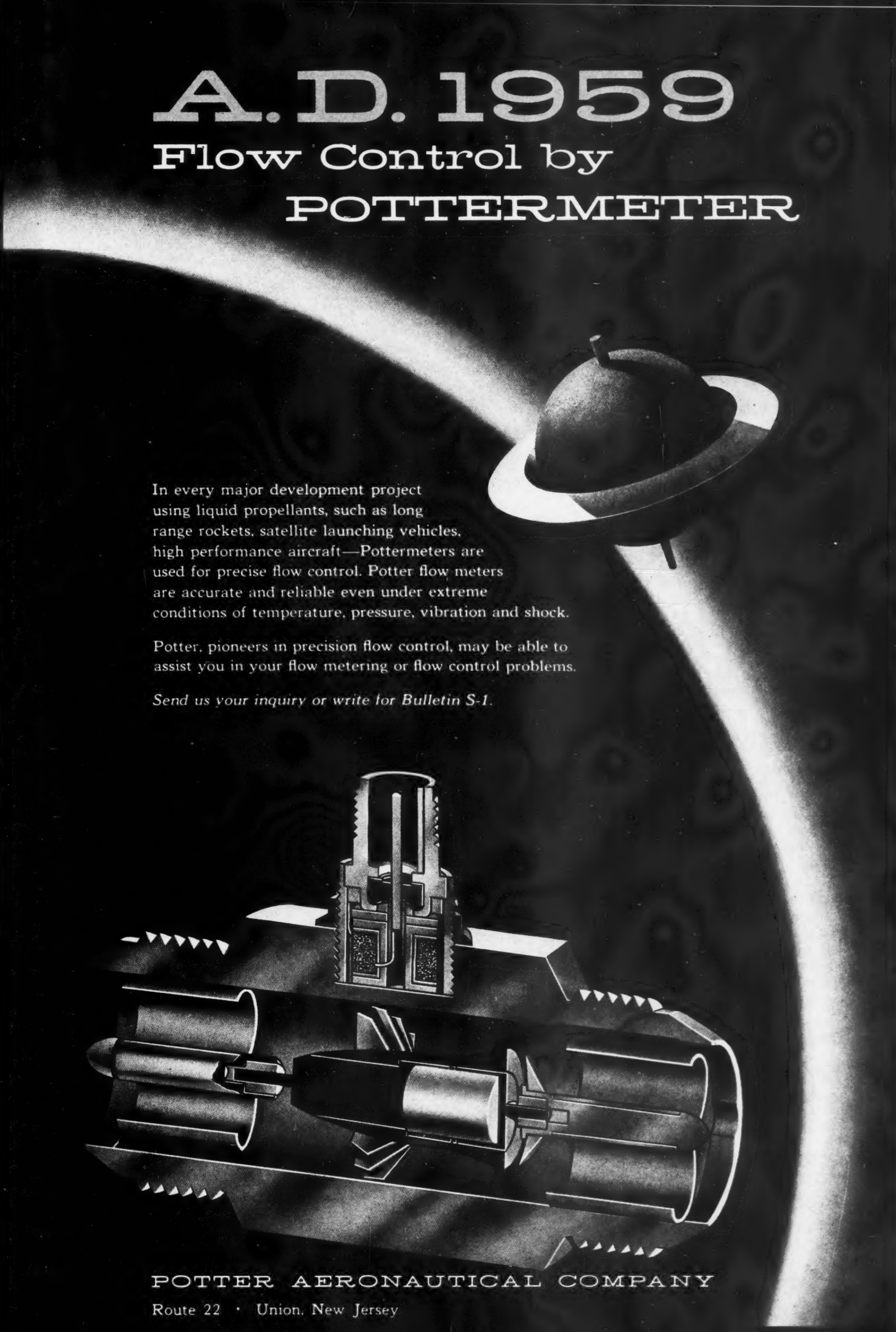
Karel J. Bossart, technical director of Convair-Astronautics, predicted that "the only time rocket vehicles will be used to transport appreciable tonnage will be in order to put a payload in a satellite orbit." He believed that the limiting size of a missile is close at hand and suggested that "the larger missiles entering the preliminary design phase today are not far removed from the ultimate size."

Among the other speakers were H. S. W. Massey of the University College of London, W. H. Stephens, A. D. Baxter of the College of Aeronautics, N. C. Freeman, A. W. Lines, Milton Rosen and L. R. Shepherd.

The sessions were complemented by a rocket and aircraft exhibit, static firing demonstrations, fueling demonstrations and a film on rockets.

on the calendar

1957	
Sept. 8–13	National Meeting, ACS, New York, N. Y.
Sept. 15–18	Regional Meeting, AIChE, Baltimore, Md.
Sept. 23–25	Fall Meeting, ASME, Hartford, Conn.
Oct. 1–5	Aeronautic Meeting, Aircraft Production Forum and Engineering Display, SAE, Los Angeles, Calif.
Oct. 7–9	National Electronics Conference, Chicago, Ill.
Oct. 7–12	**Eighth International Astronautics Congress, International Astronautical Federation, Barcelona, Spain.**
Oct. 10–12	Fuels Conference, ASME, Quebec City, Quebec, Can.
Oct. 21–23	Power Conference, ASME, Allentown, Pa.
Oct. 28–29	East Coast Aeronautics and Navigation Conference, IRE, Baltimore, Md.
Oct. 30–31	Annual Technical Meeting, Electronic Devices Group, IRE, Washington, D. C.
Nov. 6–8	Fuels and Lubricants Meeting, SAE, Cleveland, Ohio.
Nov. 11–13	Instrumentation Conference and Exhibit, IRE, Atlanta, Ga.
Nov. 25–26	Joint Meeting, IAS and Canadian Aeronautical Institute, Montreal, Quebec, Can.
Dec. 1–6	Annual Meeting, ASME, New York, N. Y.
Dec. 2–5	**American Rocket Society 12th Annual Meeting, Hotel Statler, New York, N. Y.**
Dec. 6–7	**American Rocket Society Eastern Regional Student Conference, Hotel Statler, New York, N. Y.**
Dec. 8–11	Annual Meeting, AIChE, Chicago, Ill.
Dec. 17	Wright Brothers Lecture, IAS, Washington, D. C.
Dec. 26–31	Annual Meeting, American Assn. for the Advancement of Science, Indianapolis, Ind.
1958	
March 16–21	1958 Nuclear Congress, Chicago, Ill.
March 17–20	**American Rocket Society—ASME Aviation Div. Conference, Statler-Hilton Hotel, Dallas, Tex.**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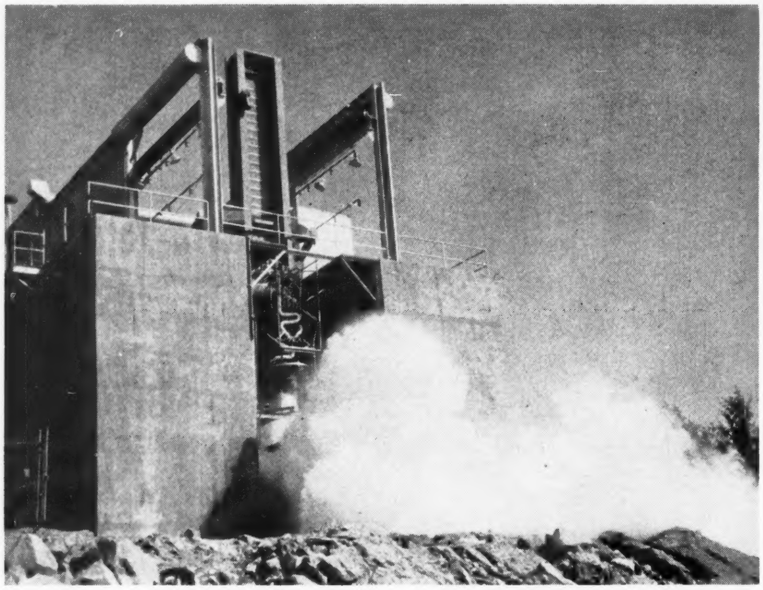


Reaction Motors' new 1,000,000-lb-thrust test stand.

New Boom for New Jersey

Already host to such explosive guests as Hercules Powder, Picatinny Arsenal, and the Naval Air Rocket Test Station, residents of northern New Jersey now have another noisy tenant to contend with—Reaction Motors' new 1,000,000-lb-thrust test stand.

Located near the company's main test area in Lake Denmark, the new stand is slated for use in development of the powerplant for the Air Force's X-15 manned rocket plane. According to RMI, the stand is capable of testing 1,000,000-lb-thrust engines in any flight attitude.

British P1 Fighter Breaks Speed Record—Unofficially

A new British fighter plane now in production for the Royal Air Force, the English Electric P1, has exceeded the world speed record of 1132 mph, its manufacturers announced last month. Actual speed reached was not announced for security reasons.

However, because the flight of the P1, a day and night all-weather interceptor, was not clocked officially for record purposes, its mark is unofficial. Thus the speed record still belongs to another British plane, the Fairey Delta 2.

AF Fires First Rocket With Atomic Warhead

The first U. S. rocket with an atomic warhead was fired recently in a test at the Atomic Energy Commission's desert proving ground at Yucca Flat, Nev. The air-to-air weapon, designated only as the MB-1 but more commonly known as the Genie, was made by Douglas and was the product of a development program previously known as "Ding Dong" and "High Card."

The rocket was fired at an imaginary target from an F-89 Scorpion, modified for the project by Northrop. No details concerning the rocket itself were made known except the fact that it has no built-in guidance mechanism. It is officially said to be in distribution among operational units of the Air Defense Command. The extent to which nuclear warheads for the rocket have been or will be distributed has not been disclosed. Presumably, it can also be fired with conventional high-explosive warheads.

Although of low power, it went off with a tremendous blast of great brilliance, forming a doughnut-shaped ring in the sky. It was exploded at an altitude of about 15,000 ft.

The Genie will complement the present defense system of ground-based antiaircraft weapons, such as the Nike, which also can be armed with an atomic warhead. The Air Force said the new weapon opened a "new dimension" in aerial warfare and hailed it as "the greatest advance since radar."

Volunteer Observers Spot Make-Believe Satellites

Volunteer observers are on the ball when it comes to tracking artificial satellites. Participating in a 90-minute training exercise as part of Operation Moonwatch, more than half the 90 stations in the nation reported sighting substitute moons to the Smithsonian Astrophysical Observatory's Moonwatch headquarters.

The simulated moons were actually $^1/_{10}$ cp lights towed by Civil Air Patrol planes at 7000 ft and at 100 mph to simulate a satellite at its brightest.

Successful X-17 Nose Cone Tests Reported by Schriever

Successful tests of nose cones in the Lockheed X-17 re-entry test vehicle were reported to the Air Force Assn. last month by Maj. Gen. Bernard A. Schriever, Commander of the AF Ballistic Missile Div. Gen. Schriever, speaking at the group's annual meeting in Washington, D. C., said that ICBM nose cones of various designs and construction have been shot hundreds of miles into the ionosphere and returned safely to earth without burning up as a result of air friction and heat development.

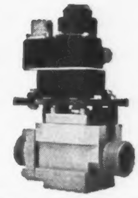
Those attending the convention had a chance to see the X-17, which was displayed at the AF Golden Anniversary Air Show at Andrews AFB, near Washington, along with the Navaho, Bomarc, Snark and other missiles and their launching equipment. In addition, flight demonstrations were given of the Ryan X-13 Vertijet and the latest jet aircraft, including the North American F-100, McDonnell F-101, Convair F-102, Lockheed F-104, and the Republic F-105 Thunderchief which was shown publicly for the first time.

Six Convair F-102 Delta Daggers arrived at the base from Chicago in the annual Bendix Trophy Race, and the show terminated with precision aerial maneuvers by North American F-100 Super Sabres.

Nickerson Gets Post In Panama Canal Zone

Col. John C. Nickerson Jr., former technical coordinator at the Army Ballistic Missile Agency, Huntsville, Ala., and central figure in the so-called Nickerson case, has been transferred to the Panama Canal Zone. In his new post, a nonmissile assignment, Nickerson will have access only to documents classified "Confidential" or lower and will not exercise any command responsibilities.

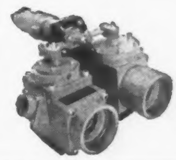
MOTOR OPERATED CONTROL VALVES



Sizes from ¼" to 1½". Ports per MS33514, AND10050, AND10056, or special configurations. DC motor with automatic current shut-off. Response times from 0.8 to 3.0 sec. Remote light position indication. Positive locking design.

*Proven reliability for missile operation.

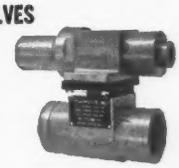
MULTI-LINE PROPELLANT VALVES



Sizes from ¼" to 4" in any combination. Motor or pressure operated. Actuating pressures from 200 to 3000 psi. Mechanically linked, simultaneous control of fuel and oxidizer lines. Available with adjustable fuel-oxidizer lead.

*Proven reliability for missile operation.

PRESSURE OPERATED CONTROL VALVES



Sizes from ¼" to 8". Ports per MS33514, AND10050, AND10056, and ASA flanges. Fast response rates from 20 milliseconds full stroke. Single or double acting actuators. Actuating pressures from 200 to 3000 psi. Remote light position indication.

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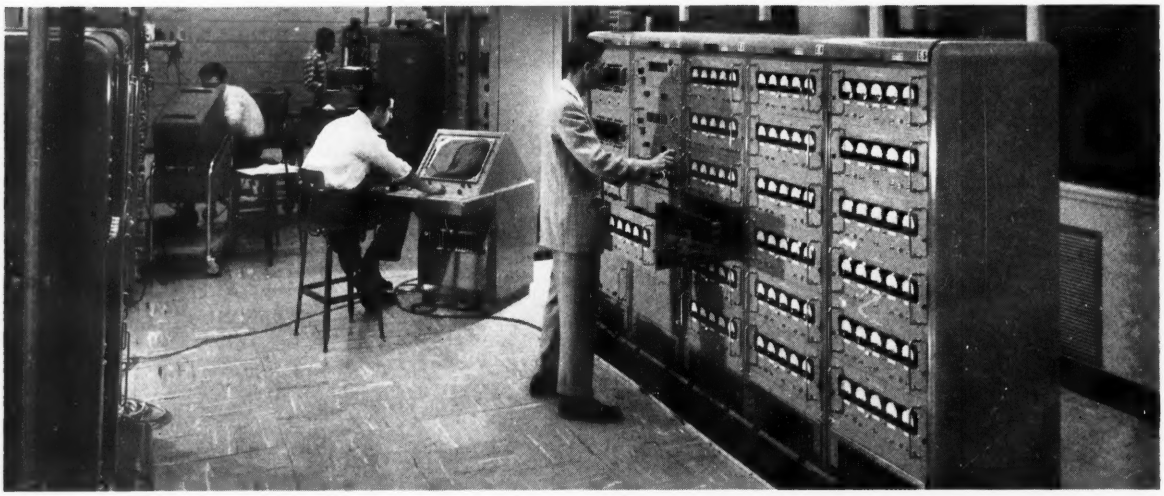


ASCOP M Series Ground Station at General Electric's Data Reduction Center

GENERAL ELECTRIC's new multi-million dollar Missile Data Processing Center — one of the nation's largest — is now engaged in advanced scientific computation and evaluation of missile flight tests.

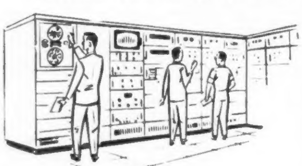
This giant Philadelphia center contains the most advanced automatic data processing and handling equipment in use today. A completely integrated operation, it greatly facilitates the speed with which vital data can be made available for analysis.

Playing an important role in this strategic operation is the ASCOP PW Data Reduction System which includes monitoring facilities. An ASCOP Ground Station handles many channels of low frequency data . . . simultaneously reduces eighty-six data channels, held to a system accuracy well within 1%. This data is originally gathered in the missile by ASCOP airborne telemetering units.

The linearity and reliability of this ASCOP system is a major factor in the advanced performance of the entire installation. And, significantly, the modular-unit flexibility of ASCOP equipment made possible delivery of the system **months in advance** of the opening of the GE Data Center . . . one more reason why it will pay you to investigate ASCOP for your present and projected programs.

ASCOP M SERIES GROUND STATION

PLAYBACK AND MONITOR GROUP • DECOMMUTATOR AND TRANSLATOR GROUP



This ASCOP PW Ground Station is a complete "packaged" system for data processing. Eighty-six Channels may be reduced in real time from tape records. Utilization of zero and full scale sensitivity reference channels affords continuous automatic system calibration, avoiding frequent manual adjustment and the need for critical components. All channels may be visually monitored simultaneously. Easy access to slide mounted chassis is featured even during operation.

"QUICK LOOK"

ASCOP Monitor Console provides a means of rapid simultaneous inspection of all eighty-six channels. Can also be supplied with a Stripper Panel which makes possible the inspection of selective channels as desired. The ASCOP Monitor Console saves data reduction time and provides important maintenance advantages.

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COVER: *Corning Glass Pyroceram missile radomes before (right) and after heat treatment. Pyroceram is typical of new materials under study for high temperature flight (see page 46).*

Astronautics

SEPTEMBER 1957

For Your Attention. . .

ARS founding member G. Edward Pendray takes a close look at what's been done to develop a peacetime rocket industry (page 20), finds it's not very much and suggests some avenues of approach to the problem.

Vice Admiral John H. Sides, now holding down a top Defense Department missile post, looks back on his experiences as a missile man and finds we've come a long way in the last 10 years (page 24).

Aerojet's Calvin A. Gongwer, one of the nation's top specialists in the field of underwater propulsion, examines some recent developments in this often-overlooked field (page 35).

An exclusive picture story (page 38) which shows in detail what's involved in rocket firings at Fort Churchill.

The second and last part of a comprehensive report on materials for high temperature flight (page 46), including a complete list of materials now in use or under study and an examination of present test methods.

A suggestion as to how we can lick the present shortage of rocket and missile engineers (page 52).

When will rockets go commercial?

It's time we turned our attention to the many and varied peacetime applications of the rocket and jet propulsion principle . . . . Here are 10 possible nonmilitary uses which already lie within our grasp

By G. Edward Pendray

PENDRAY & COOK, NEW YORK, N. Y.

TEN years ago, in 1947, in connection with some work undertaken for the Daniel and Florence Guggenheim Foundation, I conducted an opinion survey among the leaders of the then infant rocket and guided missile industry, to find out their current thinking on the future of the industry.

Out of that study and subsequent discussions came the establishment of the Daniel and Florence Guggenheim Jet Propulsion Centers at Princeton University and the California Institute of Technology. These were the first centers of graduate education and research in rockets and jet propulsion in the country, and the source of many of today's outstanding rocket and missile engineers.

Recently, I had occasion to read over again the results of my 1947 survey of rocket leaders' opinions. I was much interested in the ideas and forecasts made at that time, and I think readers of ASTRONAUTICS will find them interesting, too.

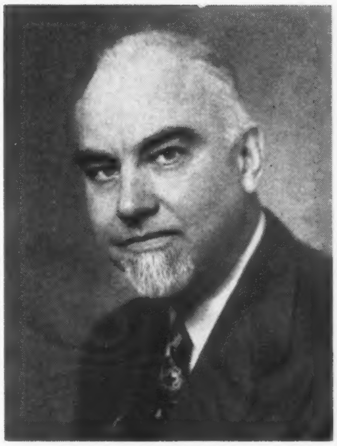
Twenty-six per cent of those interviewed foresaw significant advancement in the following 10 years (the decade ending in 1957) leading toward the development of rockets capable of orbital or interplanetary flight.

Sixty-seven per cent predicted attainment of transonic and supersonic speeds within 10 years by military, commercial and perhaps even private aircraft.

Eighty-three per cent anticipated the development of improved propellants during the 10-year period, "such as to make possible improved rocket performance, longer ranges, and higher efficiencies."

In their forecasts, the rocket engineers of 1947 were obviously on the right track, but too conservative. Possibly our views of today on what will take place in the next decade are similarly lacking in daring and imagination.

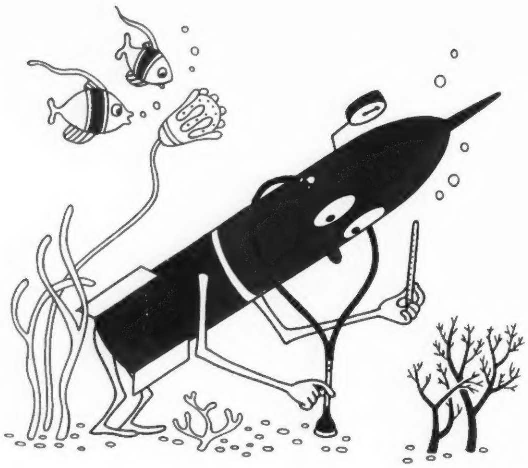
However, the principal prediction of that 10-year-old survey has not as yet been realized—and on the surface at least, seems no nearer realization than in 1948.



G. Edward Pendray has been identified with rockets and jet propulsion for more than 30 years. One of the original group of rocket experimenters who founded the AMERICAN ROCKET SOCIETY in 1931, he has served successively as its president, secretary, treasurer and board member, and for several years edited the old ASTRONAUTICS, forerunner of the present ARS publication of the same name. He helped design and build several of the Society's early liquid fuel rockets and has been a leader in sponsoring and stimulating movements for the more rapid acceptance and development of rockets and jets.

Currently, he is consultant on rockets to the Daniel and Florence Guggenheim Foundation, and advisor to the AMERICAN ROCKET SOCIETY.

The idea of being able to buy rockets off a pushcart like hot dogs may seem far-fetched today, but until such time as we have a peacetime rocket industry, producing safe and reliable research vehicles in quantity at low cost and constantly on the lookout for new commercial applications, the rocket and guided missile industry as a whole will continue to lack a firm economic foundation.



Underwater rockets carrying research and test equipment would permit full-scale exploration, for the first time, of the mysteries of the ocean deep.

Eighty-three per cent of those interviewed said they expected development within the decade of major peacetime nonmilitary industries based on rockets and jet propulsion. Aircraft applications, industrial uses, prime mover applications, mail rockets, pilotless express rockets, passenger rockets and other civilian uses were foreseen.

Eighty-two per cent of the representatives of industry, and 80 per cent of the representatives of universities, reported in 1948 that their respective organizations were engaged in work directed toward the development of such peacetime, commercial applications of rockets and jets.

Whatever happened to those projects? Where is the peacetime, commercial industry that should have grown out of them? Will we ever have such an industry?

Maybe it was the smell of "easy" money from governmental sources that caused commercial developments in rocketry to be shelved or delayed. Maybe it was the "shortage" of engineers, the pressure for production on military contracts. Maybe it was just a feeling that somebody else would do the groundwork and pioneering. But nobody did.

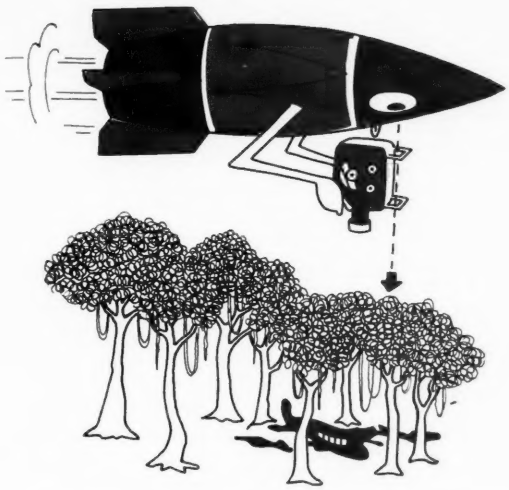
In any case, there are today almost no applications of rockets and jets that are not somehow tied up with military uses and government money. The only exceptions I know of are the still somewhat experimental development of jets for boring blast holes in rock formations, a few applications of jets or rockets for assisted take-off of civilian aircraft, and some experimental jet-driven helicopters.

Where is the passenger-carrying rocketplane, capable of traveling long distances at more than 2500 mph, the trajectory for which was calculated as long as ten years ago by Hsue-shen Tsien at Cal Tech? Where are the practical long-range mail and express rockets foreseen by experimenters and rocket engineers since the mid-thirties, and which by now should be delivering their cargoes with high accuracy and safety through guided missile techniques? Where are all the other peacetime commercial rocket developments that might be sparking the growth of a commercial industry free of the hazards of governmental budgeting and providing the economic basis for continuity and prosperity, regardless of the ups and downs of war-booms and military planning?

The rocket, jet and guided missile industry now involves well over a billion dollars in capital investment. It employs at least 50,000 engineers, scientists and other technically trained personnel. It provides jobs and livelihood for another 100,000 nontechnical workers and their families. It affects the fortunes of well over 1000 companies and firms, some wholly committed to rocket and missile work. It engages a sizable portion of the best technical and management brains and talent in the country.

Yet this entire investment in men, brains, money and materials now has no solid economic foundation to speak of, except government appropriations for weapons. The work going forward to develop ICBM's and IRBM's is making good progress, and soon these ultimate weapons will be in hand. How many of them will be needed? And when the supply required for security has been manufactured and stored away for eventualities, where will the

Rocket-based spectacles and displays could provide the advertising business with a new medium that might outdo even TV in attractiveness and impact.



Searching from medium altitudes would be facilitated through the use of special photographic rockets able to explore areas unapproachable by other means.

now-giant rocket and missile industry turn?

Surely no more time should be lost in developing the peacetime, civilian rocket industry. It should now be a major concern of everyone working in this field. The woods should be full of ideas for peacetime rockets and civilian rocket uses. But if they are, the signs of them are harder to detect than skulking Indians.

Recently, in talking about possible commercial uses of rockets and jets with a group of younger engineers at a meeting of the AMERICAN ROCKET SOCIETY, I was astonished to hear one of them say he couldn't think of any such uses—and the others nodded agreement. What should be said of the rocket industry if even its younger members cannot imagine any permanent future for it?

Possibilities Are Almost Endless

For myself, I am convinced there are many peacetime, commercial possibilities for rockets and jets. In fact, I have made a list of at least 24 such uses. Only a modicum of research and development, relatively speaking, would make some of them commercial. The enormous recent progress that has been made in missiles and high altitude rockets, in materials, fuels and guidance electronics, should soon bring most of the others within shouting distance of practical usefulness.

What principally appears to be lacking is some good, solid American daring, imagination and commercial enterprise.

Here are ten of the 24 possible nonmilitary and commercial uses of rockets and jets I have included in my private list. Admittedly, none of these ideas is new. But where, 10 years ago, most of them seemed beyond our reach, missile research and development have now brought most of them within our grasp. The developments that have taken place in the 10-year interval since 1947 can now be turned to commercial, peacetime account.

1. *Transmission of mail and express*, consisting of valuable and light cargo, over long distances at great speeds, in unmanned, guided rockets, on regular schedules.

2. *Medium altitude research rockets*, for regular weather data, pollen and dust measurements, etc. These rockets should be small and light enough for one-man operation, cheap to use, safe and reliable. They should be provided with dependable landing equipment capable of bringing the instruments and data back to earth intact, and permitting re-use of the rocket after refueling.

3. *High altitude research rockets*, light and simple, designed for safe, easy and foolproof operation, and cheap enough to permit regular use by universities, commercial laboratories, airlines, etc.

4. *Passenger rocket aircraft*, capable of operating over long distances at high velocities (speeds above 2500 mph). Essentially, these probably will be passenger-carrying guided missiles, reliable in operation and depending very little on the human pilot except at take-off and landing. They should be able to cut trans-Atlantic or transcontinental crossing to about one (CONTINUED ON PAGE 68)

One peacetime use of rockets that immediately suggests itself is transmission of mail and light but valuable cargo over long distances at great speeds.

Ten years of missile progress

A top Navy missile man looks back and finds that new philosophies, new techniques and new reliability concepts have spawned a great industry and gone a long way toward giving the Services effective weapon systems

By Vice Admiral John H. Sides (USN)
OFFICE OF THE SECRETARY OF DEFENSE, WASHINGTON, D. C.

John H. Sides, a career Navy veteran, has alternated between service with most types of naval ships and staffs at sea and shore duty concerned primarily with a progression of weapons systems since his graduation from the Naval Academy in 1925. He attended the National War College in 1948 and since that time has held a succession of key posts in both the Navy and national missile programs. In January 1956, Admiral Sides became the first flag officer to command a guided missile force at sea when he took over the Navy's newly organized Cruiser Division Six. He relinquished the command in April 1956, when he became Deputy to the newly appointed Special Assistant to the Defense Secretary for Guided Missiles. He is now director of the Weapons Systems Evaluation Group in the OSD.

THE past ten years have resulted in an almost fantastic growth in research, engineering and production of guided missiles and the ancillary equipment which is needed to give us effective weapons systems. New techniques, new philosophies, new concepts of reliability—all these have resulted in what must really be looked upon as a new industry.

During the same period, largely as a result of the birth and adolescence of this new industry, the AMERICAN ROCKET SOCIETY has undergone an equally phenomenal transition from a moderately sized group made up predominantly of amateur rocketeers to the present important technical society with its regional chapters and national organization, composed of the most expert and progressive scientists and engineers, constantly battering at the threshold of the state of the art.

It seems almost incredible that just a few years ago in the Navy program our annual budget exercise consisted in making the weighty decision as to whether, for the succeeding year, we should be allowed to build and fly 16 Terriers or 20—or a dozen Regulus missiles or 15! And I'm sure it was the same with the Army and the Air Force.

Sought Answers to Vexing Problems

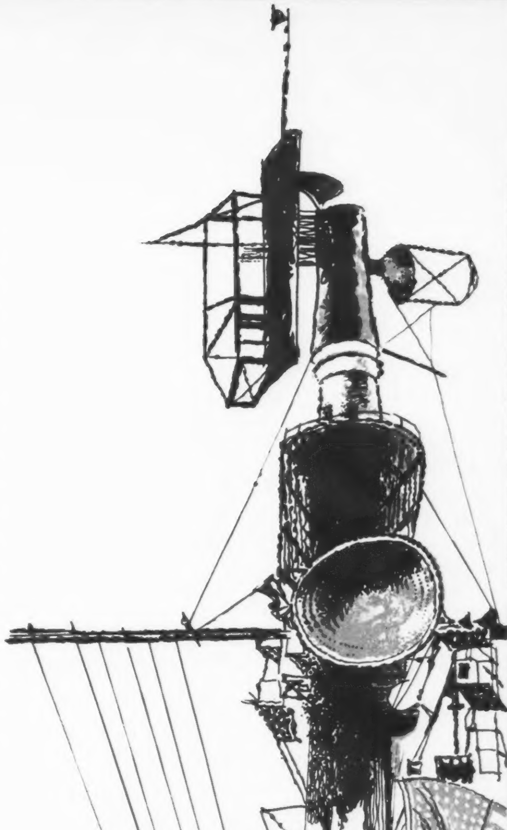
There was so much we didn't know in those days. The monthly reports from all projects were carefully scanned by all hands to see if perhaps there might be a clue to the solution to some particularly vexing problem. In those projects where the target was to be an airplane, it was generally felt that a seeker would be a wonderful thing—but nobody knew how to fabricate a satisfactory supersonic radome. The severity of the environment within a missile in flight was little understood, and flight failures were almost the rule, rather than the exception.

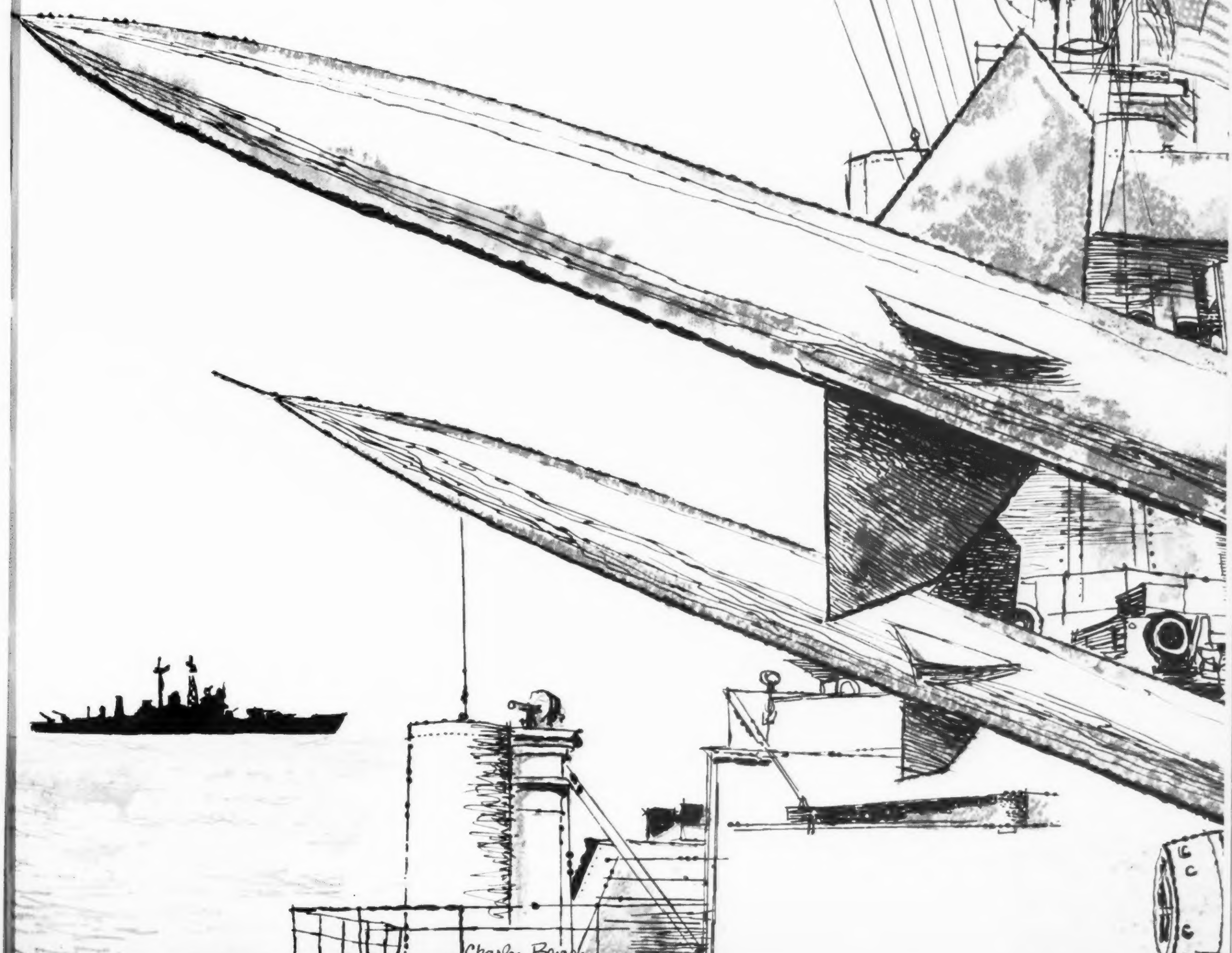
Fundamental and basic research, along with solid engineering

progress, gradually changed this picture and finally, in 1950, K. T. Keller of Chrysler Corp., whose prowess in the production field was nationally recognized, was brought in as the Director of Guided Missiles for the Department of Defense. I had the great privilege of serving with Mr. Keller in this assignment and I look back upon it as one of the most valuable experiences of my career. His job was a tough one and he was just the man for it.

The terms of reference were simple. Assuming we might find ourselves at war within three years, what could we do about it missilewise? A lot of people were really "shook up" when Mr. Keller selected three projects, ordered facilities prepared for fabricating a thousand of each per month on a single shift, and authorized the placing of orders, in one fell swoop, for a thousand of each. These missiles could hardly have been considered ready for production at the time, and a lot of gray hairs resulted from the operation.

We did not have the war, so it is difficult to assess the absolute result, but I am convinced that in the particular programs selected for "Kellerization," as well as in all others (which he also monitored), this era was really the beginning of the realization of a meaningful guided missile capability for our nation years sooner than





A MISSILEER'S DREAM is how the author describes his assignment as Commander of the first Navy guided missile force. Here, he looks over his command.

would have been possible on a business-as-usual basis.

The first half of the present decade saw our first missile projects come to fruition. Soldiers, sailors, airmen and marines were thoroughly trained and deployed at home, overseas, and into the fleet and aircraft squadrons. Our biggest problem—whether or not our personnel could continuously maintain and operate these intricate systems—turned out to be not nearly so serious as had been expected, and we were in business.

Reliability and maintainability probably will always be our greatest worry, but good progress has been and continues to be made.

Certain of our earlier models already are on the verge of replacement by vastly improved versions. But we must be extremely careful that we don't kid ourselves in our quest for better weapons by accepting increased complexity. The trend must be in the other direction; we must strive for simplicity, and lower costs, and greater reliability. To quote Admiral Arleigh Burke, Chief of Naval Operations, in a recent address, we must not design ourselves out of business.

Late in 1955, after three and a half years as Director of the Navy Guided Missile Division in the Office of the Chief of Naval Operations, I received a set of orders which were a missileer's dream. I was ordered to become the first flag officer ever to command a combatant guided missile force. As Commander, Cruiser Division Six, which was to consist of the guided missile cruisers Boston and Canberra, and the cruiser command ship Northampton, I was to have the opportunity to help develop the doctrines and tactics which would form the basis for what might become a new era in naval warfare. It was a marvelous experience. Some of you who read this article will remember your visit to Guantanamo, where you witnessed the performance of a splendidly designed weapon system, built compactly into a fighting ship, and capable of a level of air defense pre- (CONTINUED ON PAGE 76)

It's really empty space

Interim report on search for natural earth satellites indicates space near earth may be free of debris up to a certain size

AN INTERIM report on the search for small natural satellites of the earth, conducted by the Physical Science Laboratory, New Mexico College of Agriculture and Mechanical Arts, under the direction of Clyde W. Tombaugh, and sponsored by the Army Office of Ordnance Research, provides some comforting thoughts for scientists and engineers working on space flight problems.

The search, conducted at Flagstaff, Ariz., beginning in 1953, covered much of the space about the earth, and most of this area has been found empty of material moving in the most likely orbits and large enough to be seen by the equipment used, Prof. Tombaugh notes in the report.

"The chance of a discovery of astronomical or geodetic value was from the beginning regarded as very small," he writes in the conclusion to the report. "But a completely negative result, a determination that the space near the earth is free of debris up to a certain size, could have comforting significance to . . . proponents of space travel."

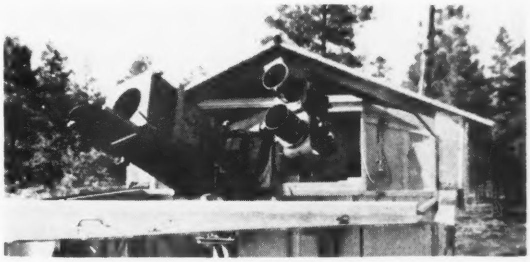
In the course of the search, a very large number of photographs has been taken of 120 "zones" of the sky, with the direction and tracking rate of the telescope adjusted for each exposure to a reasonable hypothetical satellite orbit. A few dozen suggestive images were recorded and consequently several zones were rephotographed in an effort to recover the satellite "suspects." However, none of the suspects thus far has been positively confirmed.

Work Is Being Continued

Suspects not yet completely eliminated are those which cannot be checked adequately until the search equipment has been set up near Quito, Ecuador, where the work is being continued. The proximity of this location to the equator will greatly simplify the geometrical problems involved in making the search.

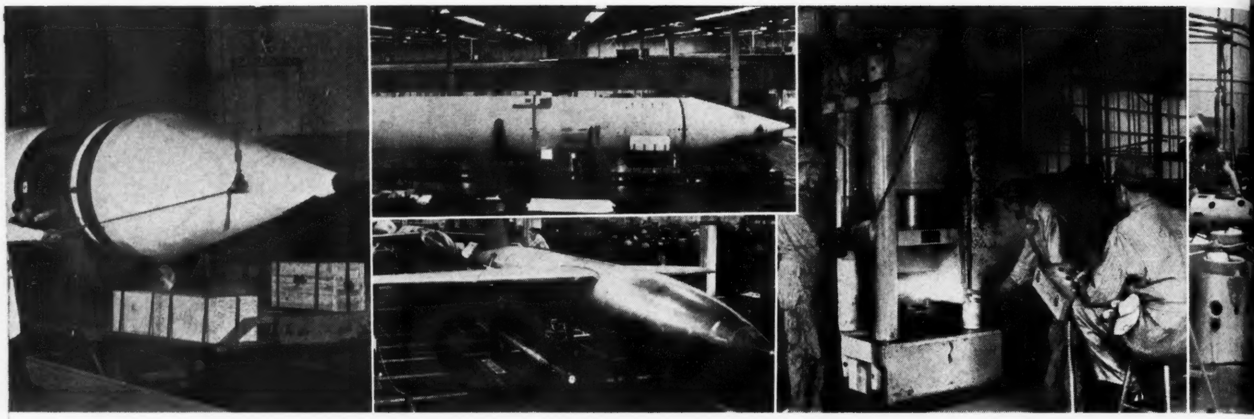
The work at Flagstaff, which pioneered satellite observation projects, resulted in the evolution of a new type of observational science. A total of 11 specific observational schemes, only a few of which were visualized when the project got under way, have been evolved. Hence the practical aspects of the search, i.e., getting set up for satellite observations, are expected to be of considerable use in the establishment of future observation stations for artificial satellites of the earth.

Prof. Tombaugh had suggested that such a search be instituted five years ago to ascertain the hazards satellite vehicles might encounter and particularly to prevent misidentification of artificial with natural satellites.



Photographic equipment used in search for natural satellite of earth at Lowell Observatory, Flagstaff, Ariz. F 1.6 Schmidt camera is at left, with two F 2.5 K-24 aerial cameras at right.

Schmidt negative No. 4182 of Zone 81, driven at 190 deg per hour to match apparent speed of hypothetical satellite at geocentric distance of 6900 statute miles in plane of equator. Trail of bright meteor shows in lower left part of frame.



Missiles mean business

The nation's fastest-growing industry will soon step into the $3 billion-a-year category. . .Here's a rundown on the missile makers and a look at what the future holds in store for them

By Michael L. Yaffee

SOMEWHAT awed, American industry is today witnessing the rapid rise of a strange new breed of businessmen—the missile makers. Ten years ago, the group as such did not exist. Today, firmly entrenched, it spearheads a fast-growing, $2-billion-a-year industry that shows little sign of slackening its pace.

Pushing its roots ever deeper into the U. S. economy, this lusty young giant is expected to reach the $3-billion-a-year level in the near future. In addition, it is spreading in all directions, showing a wild disregard for following any particular growth pattern.

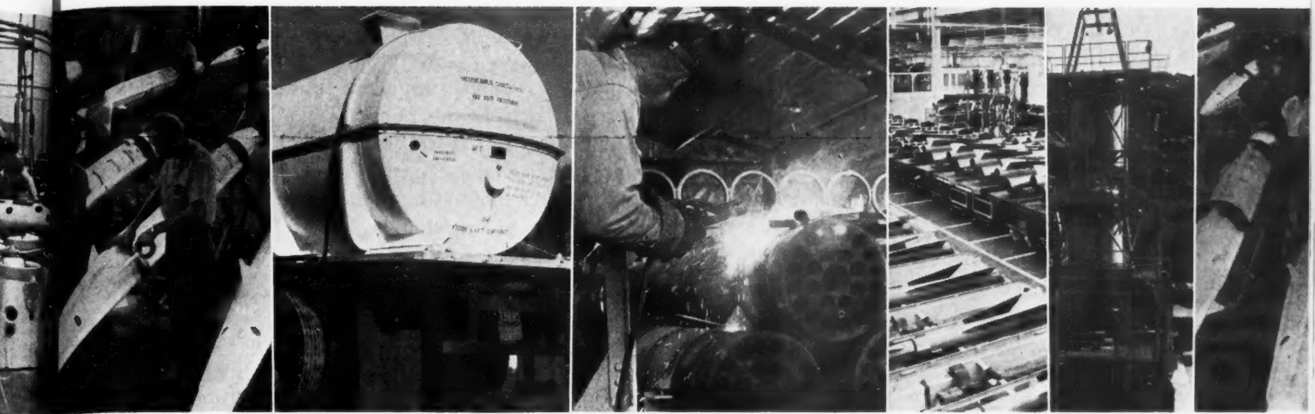
Its collective corporate background, for example, is almost as varied as American industry itself. Slicing through it, one would find aircraft companies, chemical companies, electronic firms, universities, tool firms, fabricating firms, rubber companies, petroleum firms, food firms and automobile companies. And, of course, there are a few, a very few, pioneer firms which started out as rocket companies pure and simple. But, regardless of their affiliation, most of these new firms, or divisions, are quick to forget corporate parentage and think of themselves first as missile makers.

Here, in more detail, is a closer look at the montage that is today's missile business.

As might be expected, aircraft firms dominate the missile picture. One such firm, Lockheed Aircraft Corp., like most of the others in this group, found the transition from planes to missiles an easy one, and today is one of the leaders in the field.

Lockheed set up its Missile Systems Div. as a separate group in late 1953. In the past two years, the division has multiplied its sales sevenfold. The division reported sales of $53 million for last year, expects this figure to jump to $75 million for 1957, and then double in the next two years.

Actual contracts already placed with the division now total about 15. Military secrecy shrouds many of these, but it is known that Lockheed holds a contract for the development of the Navy's Polaris



IRBM, for which the company has been designated prime contractor. Other contracts are for the production of X-7 ramjet test vehicles and the X-17 three-stage rocket re-entry vehicle. Total missile backlog, negotiated and under negotiation, exceeds $85 million.

Moreover, Lockheed, having let itself into the missile business, now looks like it may be led into the electronic field. In a recent speech before a group of security analysts, Board Chairman Robert Gross mentioned that Lockheed might purchase an electronic company to gain additional competence in this field. With 25 per cent of aircraft costs and 50 per cent of missile costs tied up in electronics, Gross noted, the electronics field seems like the best expansion bet for the firm.

Electronic Firms Move In

Meanwhile, giving substance to Gross' observation, the electronic firms have moved into the missile business from the opposite direction. An unusually successful example of this approach is Raytheon Mfg. Co.

Raytheon started working on missile guidance systems toward the end of World War II, and used this as an entering wedge to prime missile production. Today, as a result, Raytheon's Missiles Systems Div., still a major subcontractor in the field, has become the company's fastest growing group. At present, Raytheon holds two prime contracts—one for the Army's surface-to-air Hawk, the other for the Navy's air-to-air Sparrow III.

Defense Department Missile Expenditures

($ Million)

	Fiscal 1956	Fiscal 1957 (est.)	Fiscal 1958 (est.)
Army:			
Research and Development	112.0	109.0	87.4
Procurement	333.0	425.0	562.0
Total	445.0	534.0	649.4
Navy:			
Research and Development	95.2	146.2	168.0
Procurement	195.0	221.0	264.0
Total	290.2	367.2	432.0
Air Force:			
Research and Development	73.3	91.3	76.4
Procurement	641.0	860.0	1213.0
Total	714.3	951.3	1289.4
DOD Totals	1449.5	1852.5	2370.4

NOTE: These figures are on an expenditure basis, i.e., actual disbursements by the Treasury for material delivered or services performed for the government.

Moreover, the company recently announced the development of its Spacistor (see page 34), a small electronic device that is expected to play an important role in future missile guidance systems. This is expected to further bulwark the company's already solid position in the missile field.

In all, Raytheon is devoting approximately 2 million sq ft of floor space exclusively to its missile activities. Its backlog of government orders—made up in large measure of missile work—amounted to over $250 million at the start of April, up $90 million from a year ago. Moreover, missile sales are expected to show a substantial increase this year and next.

Entered Business from Related Field

Next to the transition from aircraft, entering the missile business from a related field—such as Raytheon did from electronics—is proving to be the most popular means of ingress. Another particularly successful but somewhat different example of this is Thiokol Chemical Corp.

Founded in 1929, Thiokol was the first commercial producer of synthetic rubber in the United States. From this, the company moved into the manufacture of plasticizers and other chemicals. But it wasn't until its synthetic rubbers found use as fuel binders for composite solid propellants that Thiokol became something more than another name in a chemical buyer's guide.

In 1952, Thiokol started producing rocket motors. Today, its solid propellant units are powering missiles such as the Falcon, Nike-Hercules, Nike-Cajun, Lacrosse, Terrapin, X-7 and the Matador B.

Thiokol's defense business, almost all concerned with rocket motors, has jumped from $2.4 million in 1951 to $15 million in 1956. For comparison, over the same period, civilian sales of the company rose from $2.5 million to $6.1 million. And, according to a number of analysts, Thiokol is expected to continue this trend for some time, albeit at a somewhat slower pace.

The direct approach to the missile business—and, judging from statistics, the least popular—is best typified by Aerojet-General Corp. Although now a subsidiary of General Tire, Aerojet began life as a rocket company, unencumbered by conventional parentage.

Although considered a pioneer in the missile field, Aerojet is still a comparative youngster alongside most of the corporations now in the field. But, showing an ability far beyond its corporate age, the

Who's Making What for U. S. Missile Program

This table gives a picture of the extensive and varied nature of the large and still-growing missile industry. It is offered as a guide to show the relationship of some major contractors to particular projects and to each other. It is not intended to be a complete and comprehensive listing. Much of the work is still classified, and the relationship of many companies to the program, while vital, is nevertheless too indirect to be noted here.

Company	Project	Remarks
ACF Industries, Inc.	Sidewinder	Development of guidance and control system
	Bomarc, Redstone	Design, development, and prototype fabrication of safety and arming devices
Aerojet-General Corp.	Bullpup	Solid propellant engine
	Titan, Thor	Powerplant research and development
	Polaris	Major contractor
	Bomarc	Liquid propellant booster
Aerophysics Development Corp.	Dart	Prime contractor
American Bosch Arma	Titan	Development of inertial guidance system
American Machine & Foundry Co.	Talos	Subcontract from RCA for launchers
	Nike	Accessory power drives
	ICBM, IRBM	R & D on auxiliary power units
Avco Mfg. Corp.	Falcon	Supplies components
	Titan	Nose cone development
Baldwin-Lima-Hamilton Corp.	Polaris	Contract for ship motion simulator
Bell Aircraft Corp.	Rascal	R & D contract
	Regulus I, Regulus II, Atlas	Radio equipment under subcontract
Bendix Aviation	Talos	Prime production contract
Boeing Airplane Co.	Bomarc	Prime contractor

company early swept into a position of leadership, and today, according to its president, Dan Kimball, is the "most completely integrated rocket and missile fuel company in the industry, including liquid, solid and underwater rockets."

Sales in 1956 were $144 million—more than double 1955's $69 million. Low-profit development contracts accounted for much of this. Even so, the firm's net profit was up 50 per cent to $3.2 million. This year, the company expects to do even better than last. Profits for the first half, ended May 31, were $1.7 million, compared with $1.6 million for the first half of fiscal 1956. Sales were $80 million as against $63 million in 1956. Total sales for 1957 are figured to hit $160 million, up 11 per cent from last year. (For comparison, sales in 1952 amounted to $30 million, and profits were $698,000.) In addition, the company expects greater profits to result from the rising ratio of more profitable production contracts to low-profit development contracts.

Aerojet began 1957 with 506 contracts on hand, compared with 176 at the start of 1956. Its total backlog of orders now exceeds $500 million. And, according to one official at General Tire, Aerojet is slated to get additional big military contracts soon.

Meanwhile, the company is working under contract on powerplants for Thor and Polaris IRBM's and for the Titan ICBM; producing solid propellant rocket engines for the Bullpup and the second-stage liquid propulsion system for the Vanguard earth satellite vehicle; filling a multimillion-dollar order for its perchlorate-based JATO units and spare igniters; and still providing Aerobee and Aerobee-Hi sounding rockets for upper air researchers.

Typify Present Missile Firms

In essence, the approaches of these four firms typify almost all entries in the missile business. The four companies themselves, however, constitute only a small percentage of those actually active in the field at present. (For some others, see table below.)

All these companies and the men that work for them have in common top security clearances, a consuming desire to make missiles that will carry bigger payloads faster and farther than anything now in the air, and the same customer—the government.

This year, the administration had hoped to spend almost $3 billion on research, development and procurement of a multitude of missiles. But Con-

Company	Project	Remarks
Bridgeport Brass Co.	Zuni	Rocket motor tubes
	Sidewinder	Motor parts
Burroughs Corp.	ICBM, IRBM	Data processing system for AF ballistic missile program
Chance Vought Aircraft, Inc.	Regulus I, Regulus II	Prime contractor
Chrysler Corp.	Redstone	Prime contractor
	Jupiter	R & D contract
Convair Div. of General Dynamics	Atlas	Development contract for airframe and airframe components
	Terrier	Prime contractor
	Tartar	Engineering and production contract
Cook Research Laboratories	IRBM	Research on re-entry problem
	ICBM	R & D on testing inertial guidance systems
Douglas Aircraft Co.	Nike-Hercules	Missile, airframe and launching components
	Thor	Development contract
	Nike-Ajax	Airframe
	Honest John, Ding-Dong	Prime contractor
Eastman Kodak	Dove	Prime contractor
Elgin National Watch Co.	Sidewinder, Sparrow	Timing mechanisms
	Nike	Safety and arming devices
Emerson Electric	Little John	R & D work
Fairchild Engine and Airplane Corp.	Petrel	Prime contractor
	Goose (or Blue Goose)	Development; reported to be prime contractor
		Also has Army R & D contract for drones
Firestone Tire & Rubber Co.	Corporal	Prime contractor
Food Machinery & Chemical Corp.	Thor	Development of ground handling equipment
	Hawk	Transporter
		Company also produces hydrogen peroxide and UDMH for missile program

(CHART CONTINUED ON FOLLOWING PAGE)

Who's Making What (CONTINUED)

Company	Project	Remarks
Freuhauf Trailer Co.	Matador	Launching equipment
General Electric Co.	Sidewinder Polaris Atlas, Thor Atlas	Guidance and control systems Major contractor; development of fire control and guidance systems Nose cone development Guidance system
General Motors	Matador, Snark	Turbojet engines Also has contract for support facilities for ballistic missile program
Gilfillan Brothers	Corporal	Guidance system
Goodyear Aircraft Corp.	Nike	Boosters
Grand Central Rocket Co.	Dart	Solid propellant motor
Hercules Powder Co.	Honest John	Solid propellant motor
Hicks Co.	Terrier	Boosters
Hughes Aircraft	Falcons	Prime contractor
International Telephone & Telegraph Corp.	Lacrosse, Talos, Bomarc, Meteor, Rascal, Sparrow	Company reports only that it is working on these systems
Interstate Electronic Corp.	Polaris	Described as major contractor by government
Kellett Aircraft Corp.	Nike	Subcontract from Douglas
Lockheed Aircraft Corp.	Polaris, X-7, X-17	Prime contractor Engaged in 15 separate missile projects.
Marquardt Aircraft Co.	Bomarc	Ramjet engines
Martin Co.	Lacrosse, Matador Titan	Prime contractor Contract for design, testing and fabrication
McDonnell Aircraft Corp.	Talos Quail	Ramjet engines R & D contract
North American Aviation, Inc.	Titan Atlas	Subcontract for ground equipment from Martin Liquid propellant engines
Northern Ordnance, Inc.	Terrier	Launching system

gress, caught in an economizing mood, wouldn't go along and instead directed the Defense Department to cut back its proposed budget for fiscal 1958. The full effect of this cutback on the various missile programs remains to be seen. But there are some straws already in the wind.

Among the first to feel the ax, of course, was North American's Navaho, a guided missile of intercontinental range. After having spent a reported $500 million on the development of this ramjet missile, the Air Force is apparently abandoning it in favor of the slower, turbojet-powered Snark. Similar to the Navaho in range and payload capabilities, the Snark, unlike the former, had already passed through a successful test program. The Air Force, backing its decision with a $73-million production order to Northrop, plans to place Snarks in operational units of the Strategic Air Command as soon as the missiles start coming off the assembly line.

The Air Force has also dropped the Jupiter IRBM from its proposed 1958 budget. Subject of much Army-Air Force controversy, the Jupiter program, however, is still not dead. DOD reportedly has promised to supply funds from its own emergency research and development reserve so that the Army may continue support of the program at least through the first half of fiscal 1958.

Another AF missile that may have trouble finding funds for future production is Bell's air-to-ground Rascal. Considered a "marginal weapon" by some authorities, the Rascal is scheduled to phase out of research and development and into operational status shortly.

Long-Range Missile Affected Least

Least likely items in the AF arsenal to be affected by any budgeteering, of course, are the long-range ballistic missiles. The House Appropriations Committee, for instance, originally trimmed $70 million from funds requested for AF missile procurement but directed that none of this cut be applied to bal-

Company	Project	Remarks
Northrop Aircraft, Inc.	Hawk	Principal subcontractor
	Snark	Prime contractor
Pan-American World Airways, Inc.	———	Runs Patrick AFB missile center for Air Force
Philco Corp.	Sidewinder	Guidance and control systems
Radio Corp. of America	Talos	Ground guidance radar system
		Runs missile test range at Patrick AFB under subcontract from Pan-American
Ramo-Wooldridge Corp.	Atlas, Titan, Thor	Systems engineering and technical direction for AF ballistic missile program
Raytheon Manufacturing Co.	Hawk, Sparrow III	Prime contractor
Republic Aviation Corp.	Atlas	Nose cone subcontract from GE
Ryan Aeronautical Co.	Firebee	Prime contractor
	Corporal	Rocket motors
Rheem Manufacturing Co.	Surveillance drone	Army contract
Radioplane Company	Target drones	Army contract
	XQ-4	AF contract
Sperry Rand Corp.	Titan, Thor	Guidance systems
	Sparrow I	Development and production
Temco Aircraft Corp.	Corbus	Development contract
Thiokol Chemical Corp.	X-17, Lacrosse, Nike-Hercules, Falcon	Solid propellant motors
	Matador B	Booster
	Hawk	Contract for R & D work on solid propellant unit
United Aircraft Corp.	Snark	J-57 engine
Western Electric Co.	Nike-Hercules	Prime contractor
	Nike-Zeus	Development contract
Westinghouse	Polaris	Contract for experimental launching system

listic projects. And as things now stand, the Air Force plans to spend almost half of its allotted 1958 missile procurement funds just on Atlas, Titan and Thor.

This, of course, is the big reason behind the cutbacks in other AF missile programs. As for the money not slated for ballistic projects, there are just too many competitive missile programs for them all to be covered adequately.

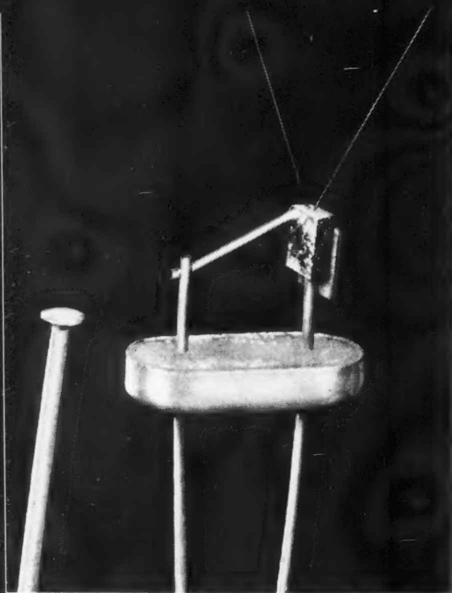
One missile that will be covered by funds for the current year is Boeing's new interceptor missile, the Bomarc. The Air Force has already awarded the company a production contract of $139.3 million. It is also likely that some AF money will go into procurement of the Navy's Sidewinder. Some other projects that will probably continue to receive AF funds are the Goose, Matador, the GAR series and a number of drones.

And, of course, the various anti-ballistic-missile missile programs are almost as untouchable as the ballistic missiles themselves. Both the Air Force and Army have top priority ballistic missile defense programs under way which recently were coordinated through a joint Army-AF committee headed by a representative from the office of the Secretary of Defense. For its part in the program, the Army has tentatively scheduled $12 million out of 1958 R&D funds. Important as the program is considered by top officials, this sum is still $8 million less than the Army had originally requested for the program.

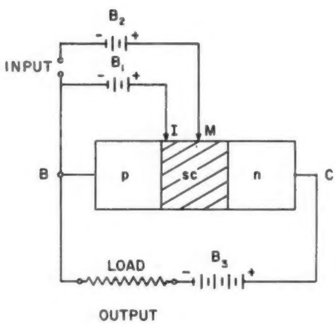
Will Be Under 1957 Budget

Over-all, the Army's 1958 missile R&D budget will probably run about $25 million under last year's $109 million, due primarily to the transfer of the Jupiter program to the Air Force. At the same time, proposed missile procurement by the Army has jumped almost $140 million from last year's $425 million. The emphasis this year will be on ground-to-ground and ground-to-air missiles.

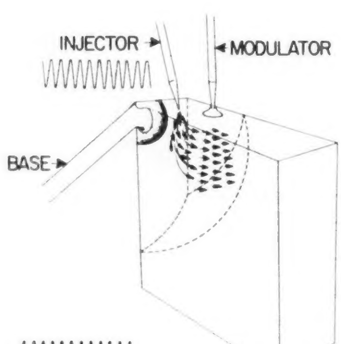
Among other things, the (CONTINUED ON PAGE 94)



Spacistor's size as compared to that of a pinhead (left) and of the boatlike transistor mount below it.



Typical experimental Spacistor and external circuits.



Isometric sketch of Raytheon's Spacistor.

Successor to the transistor?

New Spacistor may find wide use in missile field if its theoretical amplification and high temperature capabilities are fully realized

A TRANSISTOR-like semiconductor that works like a vacuum tube was revealed by Raytheon Mfg. Co. last month. Termed the Spacistor, it was heralded as a startling scientific breakthrough with vast potential in the electronics field, primarily because of two predicted capabilities:

Amplification of signal frequencies up to 10,000 mc, as much as 50 times higher than transistors commercially available today.

Operation over temperature ranges up to 500 C, more than double the limit of the present germanium and silicon transistors.

These figures are based only on theory. Less than a dozen of the tiny germanium Spacistors have been built, and three to five years may pass before they reach the general market. Low temperature and low frequency operation of the experimental devices have followed theoretical expectations closely, however, the company stated, lending weight to predicted values.

In the missile business, both the amplification and the high temperature abilities of the Spacistor would be very welcome for raising the present limits on those vital parameters. Further, Raytheon said there appears to be nothing intrinsically more expensive in the Spacistor than in the transistor.

Claim Other Advantages over Transistor

The electronics manufacturer claimed other advantages for its invention over the transistor: Very high input impedance, measured at 30 megohms in the experimental units, with higher values believed probable; and very low output capacitance, indicated to be less than 1 micro-microfarad.

Experts tend to accept Raytheon's prediction of high temperature operation. There is some difference of opinion as to whether the high frequencies can be achieved. But it was noted that Bell Telephone Labs, inventor of the transistor, patented a field effect transistor in 1952 that was reported to amplify comparable frequencies. It was made of silicon carbide, the same material that Raytheon cites to support its claim for high temperature capabilities. Relatively little demand for the new transistor has been found.

Physically, there is little difference in size, weight or appearance between a transistor and a Spacistor. Both consist essentially of tiny blocks mounted on a base. The Spacistor block has four contacts, the transistor has only three. (CONTINUED ON PAGE 56)

Aerojet's pump jet boat. While efficiency of internal jet engine is limited, ability to rotate thrust nozzle through 360 deg provides advantage over propeller-driven craft.

Underwater propulsion moves ahead

While development of rockets and jet engines for use in water still poses problems, much progress has been made in the past few years

By Calvin A. Gongwer

AEROJET-GENERAL CORP., AZUSA, CALIF.

Calvin A. Gongwer's work in the field of underwater propulsion dates back more than 15 years. After graduating from Columbia University in 1937, he attended the California Institute of Technology, where he was employed in the Institute's Hydraulic Machinery Laboratory while working toward a Master's degree. Upon graduation in 1939, he joined the Research Laboratories Division of General Motors. In 1941, he became a member of the scientific staff of the U. S. Navy Underwater Sound Laboratory at New London, Conn. He joined Aerojet in 1945 and is now manager of the company's Underwater Engine Division. Mr. Gongwer is the co-inventor of the MiniSub described in this article.

WHEN Aerojet-General president Dan A. Kimball told AMERICAN ROCKET SOCIETY members meeting in San Francisco that he envisioned rocket-propelled underwater missiles traveling at very high speeds in the not-too-distant future, he focused attention on one phase of rocket development which has not yet received the attention it deserves.

That is the field of underwater propulsion. While most rocket engineers know that highly efficient underwater missiles are perfectly feasible, they may not be familiar with the progress that has been made during the past few years in the design, development and testing of underwater propellers, rockets and jet engines.

To introduce the subject of underwater propulsion, some comparisons should be drawn with aerial propulsion. Although both air and water are fluids, propulsion through the two media is very different. Except in certain types of powerplants, such as the nuclear submarine, which is beyond the scope of this discussion, there seems to be no comparison between the progress made in water propulsion and that made in aerial propulsion. For instance, the speeds of ships and aircraft are obviously quite different.

These differences between air and water propulsion are brought out strikingly by comparing marine and aerial propellers. The cloverleaf marine propeller, with its high solidity (meaning projected blade vs. disk area), contrasts strongly with the aircraft propeller. Moreover, its efficiency is lower. The reasons for this contrast lie first in the higher thrusts per unit frontal area, which require greater blade strengths, and, second, the limits that are imposed on peripheral speeds by cavitation velocities.

The cavitation velocity in water, at sea level, is only about 47 fps

Ram scoop, with trash rack removed, and nozzle turret of pump jet boat.

and increases as the square root of the absolute submergence. This velocity is somewhat analogous to the speed of sound in air, and shapes and foils which are resistant to cavitation are also resistant to compressibility effects in air. It should be pointed out that the speed of sound in water is 4800 fps, so that compressibility is not usually a problem.

As a result of the analogy between cavitation in water and compressibility in air, the thin sharp blade sections of the boat propeller are appropriate for supersonic aerial flight. A third factor is that there are usually more restrictions on the maximum diameters of marine propellers than there are on the diameter of an aerial propeller.

In support of this discussion, it may be pointed out that aerial propellers for high speeds are being made with wider, thinner blades, and that the solidity is thereby increasing. Both of these changes are in the direction of marine propeller design.

Before taking up jet propulsion in general, it is appropriate here to discuss rockets. The amazing performance of rockets has not been realized under water because the forward speeds of the underwater rockets are much less, and consequently their propulsive efficiency is only a few per cent, usually less than 5 per cent. Nevertheless, solid propellant rockets can be extremely useful under water because, first, they require no atmospheric air; second, they have a very high thrust per unit frontal area; and, third, performance does not decrease rapidly with depth for solid rockets using high chamber pressures. For the last reason particularly, solid rockets are more useful for underwater propulsion than are liquid rockets.

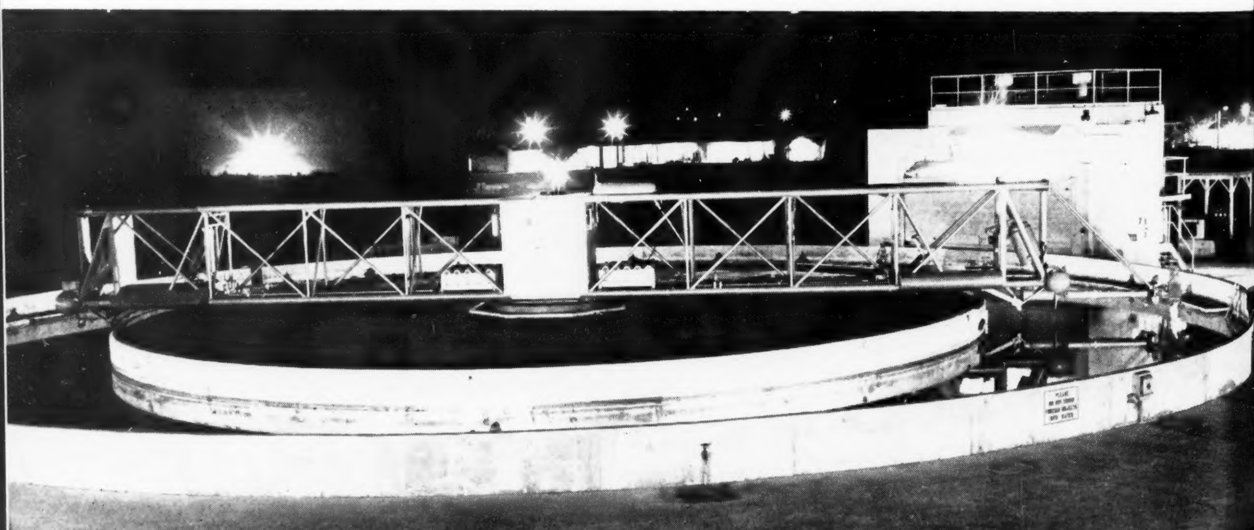
In the other areas of jet propulsion, progress under water has been made in a somewhat different direction and, in general, has lagged behind that made in air. To sum this up, several things can be said. First, shrouded propellers and pump jets are more successful under water than their counterparts, the ducted fans, because they solve the serious cavitation problem, while the corresponding compressibility propeller problem in air is already solved by the other jet engines. Second, air is both an oxidizer and a gas. Therefore, it is a useful working fluid in engine cycles, so that the jet engines are both engines and thrust producers at the same time.

Studied Analogs for Aerial Jet Engines

We at Aerojet have worked for a number of years for the Navy on the development of underwater jet engines. Analogs for nearly every type of aerial jet engine have been studied and developed as far as it appeared feasible to do so. However, this objective of developing underwater jet engines has been a difficult one because, although water is an oxidizer for certain water-reactive chemicals, these fuels are difficult to handle and therefore logistically objectionable. Further, water, being incompressible, cannot be used in an engine cycle unless it is flashed to steam, and this requires large quantities of heat energy.

Moreover, the ambient pressure increases so rapidly with depth that it is difficult to keep favorable pressure ratios in the cycle without going to

This ring channel and rotating arm facility is used by Aerojet in development work on underwater engines.



Mk VI (left) and Mk VII MiniSubs under way submerged.

prohibitively high pressures before expansion, unless the system is made condensing, with pressure and temperature of the liquid and vapor phases existing in near equilibrium conditions, as can be done with the steam cycles.

However, it is an advantage that water is a high density liquid, because it requires much less energy to raise the pressure by pumps or by ram pressurization than is required with air.

There now exists one true underwater jet engine which has overcome the technical difficulties already discussed. This is the hydroduct, or underwater ramjet, which flashes sea water, previously raised to the ram pressure by an inlet diffuser, into steam. This steam then expands rearward through a nozzle. A special, non-gassing, solid propellant is used, so that the jet is 100 per cent condensable. Very high underwater speeds have been obtained with this device. To avoid the effect of depth, which decreases the pressure ratio, the process will eventually be made condensing.

Underwater jet engine under test in ring channel at speed in excess of 60 knots.

Aerojet has built and installed a simple, engine-driven pump jet in a small boat, shown under way on page 35. An attempt was made to attain considerable speed, which is necessary if good jet efficiency is to be obtained. The jet velocity must be reasonably high so that sufficient thrust is obtained without handling too much water. Using 25 hp, a speed of 20 mph was obtained.

Operates at 2-to-1 Velocity Ratio

The jet operates at a velocity ratio of 2 to 1—that is, the relative exit velocity less the forward speed, divided by the forward speed. This ratio gives a jet efficiency of 50 per cent. The combined pump and ducting efficiency is about 70 per cent. Thus the over-all effective propulsive efficiency is about 35 per cent. The ducting was arranged for minimum hydraulic losses, and a ram scoop was used which "dumped" the boundary layer. The scoop without its trash rack, together with the nozzle turret, is shown on page 36. At the 2-to-1 velocity ratio, it is necessary to conserve the ram head by means of a scoop. Otherwise, efficiency is reduced.

This type of internal pump jet is limited to an efficiency of about 35 per cent, and it is to be compared with the competing propeller, which operates at 50 to 65 per cent efficiency. Consequently, the device must be sold on its other merits. There are several of these, such as its shallow draft, its ability to rotate the thrust nozzle through 360 deg, the safety it provides swimmers, and so forth.

There is another type of pump jet, which consists of an axial flow pump that is generally used with one or more rows of stator blades. One good application is at the rear of a(CONTINUED ON PAGE 64)

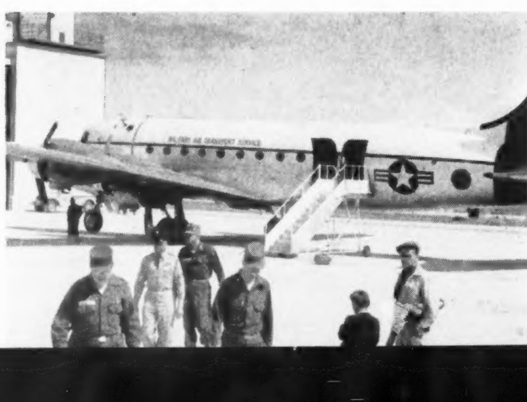
THIS IS CHURCHILL: Above the "tree line," this desolate area still sports some stunted, scrawny evergreens growing lopsidedly away from the wind. Among the ages-old rocks and boulders lie patches of rich, black muskeg in which daisy-like flowers flourish briefly in July. A few inches below this loose earth lies the permafrost, ground that is frozen the year round.

Shooting rockets in the sub-arctic

Here's the complete story in pictures of how U. S. scientists managed the job of firing the first two IGY sounding rockets at Fort Churchill

U. S. Army photographs

GETTING THERE: A MATS (Military Air Transport Service) flight is the quickest, if not the most comfortable, way. Stretched out on litters, passengers must share available space with needed cargo. Below, MATS plane arrives at Fort Churchill.



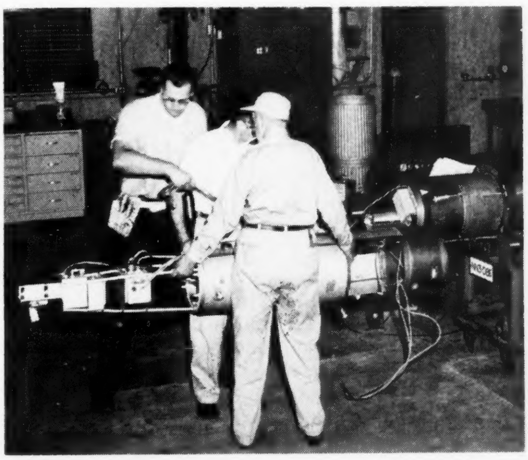
FORT CHURCHILL'S location—on the western edge of Hudson Bay in Canada, north of the 58th parallel and, by a twist of nature, north of the so-called tree line—is one which is "happily" endowed with many of the attributes of a true arctic climate. This provides the post with the prime reason for its present existence as an arctic test center for the Canadian services and, with their permission, for the U. S. Army.

Its location, the fact that supply lines and some scientific installations were already established and, most important, its comparative isolation combined to make Fort Churchill a near-ideal place for the U. S. National Committee for the International Geophysical Year to fire high altitude sounding rockets.

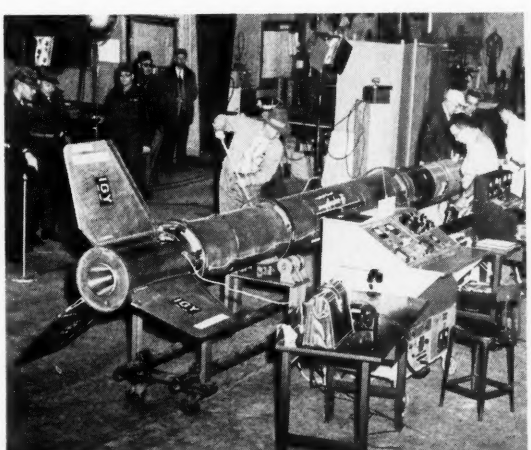
This story of the first two firings in July—part of a total of 76 planned by U. S. scientists at Churchill—graphically demonstrates what's involved in such shoots.

ROCKETS ARRIVE at local freight station after a more leisurely trip from the States by way of Winnipeg and the Hudson Bay Railway. From the station, the rockets are trucked the remaining 12 miles to the launching area.

BOOSTER IS UNCRATED in storage bunker, placed on a rubber-tired dolly and towed over to assembly area where rest of the rocket is being fitted together.

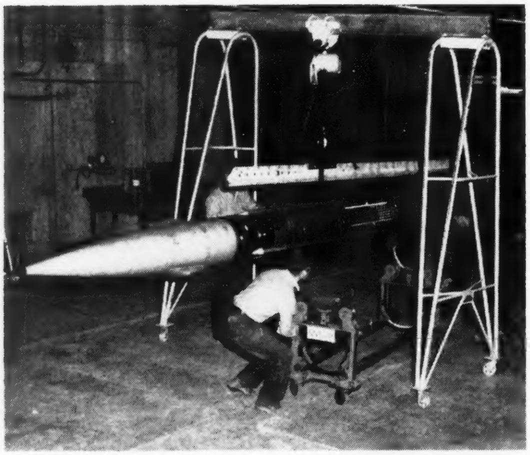


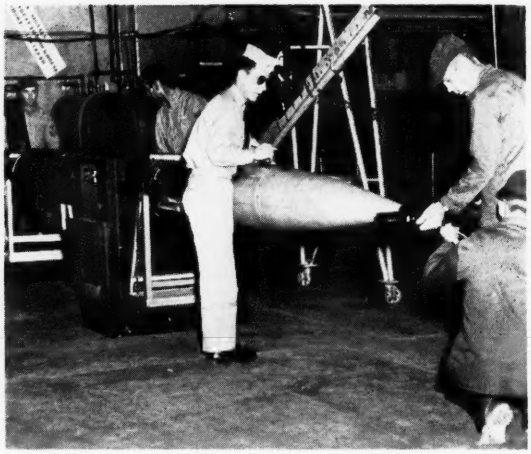
NOSE AND TAIL sections are attached to the body of the Aerobee-Hi in preparation for horizontal testing and checkout of the vehicle.



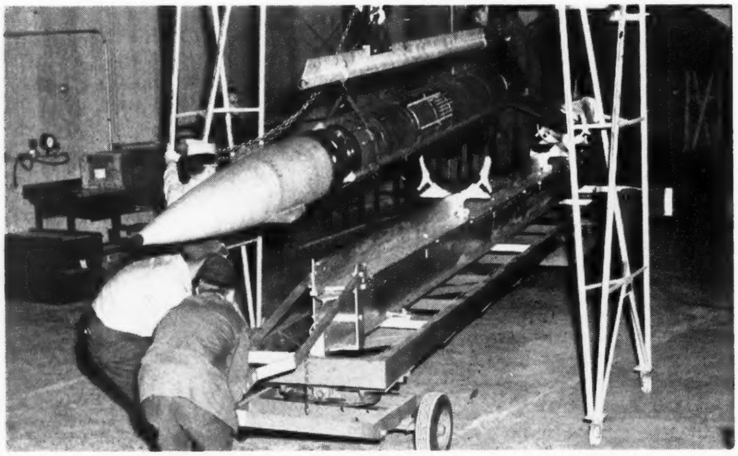
WITH FINS ATTACHED, the rocket undergoes an elaborate horizontal checkout procedure in which wiring and equipment are thoroughly tested.

TWO WHIP ANTENNAS, designed for ionospheric research, are affixed to the rocket, and the antenna erecting mechanism is checked.

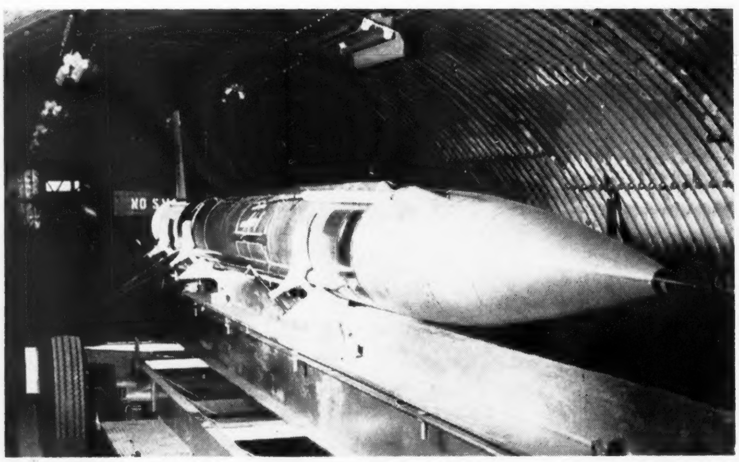




WEIGH-IN: Using a mobile hoist, workers lift rocket from its checkout dolly, transfer it to scales where the vehicle is accurately aligned, measured and weighed.

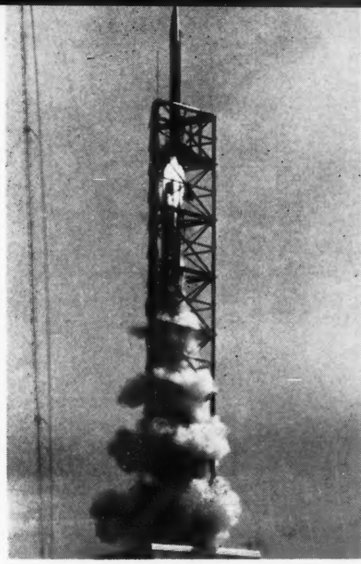


THIRD RAIL: Rocket joins the booster on trailer for last leg of the trip. Rail on trailer lifts up to become third guide arm of launch tower.



ON ITS WAY: The now-complete Aerobee-Hi moves down tunnel from assembly area to adjoining launching tower. Since pre-IGY firings last fall, sheathing has been removed from tower, and blast doors on lower housing modified.

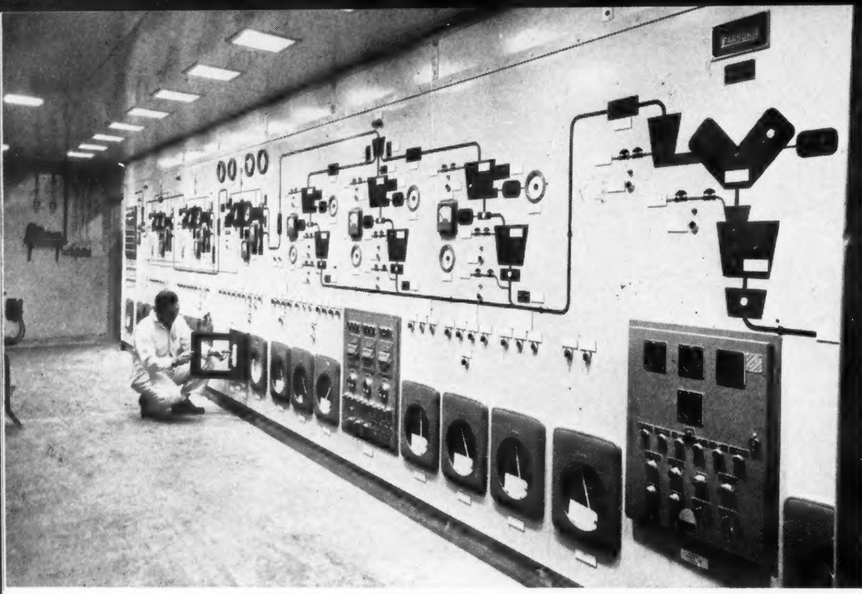
X-0: First Aerobee-Hi (right) takes off on what proves a near-perfect shoot of almost 160 miles altitude. Twelve hours later, second Aerobee-Hi (far right) blasts out of the tower only to be accidentally cut down just under 10 miles.



POST-SHOOT CONFERENCE: U. S. Army, Navy, civilian and Canadian personnel cooperating in the project do a post-mortem on the first two firings, reviewing apparent success of the first, deciding faulty range-safety device was the culprit in the second.

LEAVING CHURCHILL: MATS plane takes on fuel for flight home. It will carry cargo and passengers no longer needed at Churchill back to the States.

TIRED PASSENGER: John Jackson, Naval Research Laboratory physicist who was project scientist on first two firings, catches up on some lost sleep.



Control panel for mixing, blocking and extruding operations shows extent to which control instrumentation has been used in the plant.

Rocket motors don't have to be expensive

Here's how Phillips coupled modern production-line techniques and close control over factors affecting production expenses to hold costs down during manufacture of the solid propellant M-15 JATO

By R. S. Dobyns and J. A. McBride

ROCKET FUELS DIV., PHILLIPS PETROLEUM CO., BARTLESVILLE, OKLA.

THE rapidly growing literature on solid propellant rockets reflects a growing realization of the many advantages of such rockets and their increasing use. Their inherent simplicity and reliability assure a continuing expansion of their areas of application to propulsion requirements. These features make solid propellant rockets potentially the least expensive propulsion devices. They also make possible the successful application of many classical production-line techniques to the manufacture of solid propellant rockets.

The design of the production line for a solid propellant rocket will be the dominant factor in determining the extent to which the low-cost potential of a rocket of this type, utilizing low-cost ingredients, can be realized, for the design will dictate some production cost minima which cannot be lowered unless the line itself is improved.

Based on a paper presented at the ARS Semi-Annual Meeting in San Francisco, June 10–13, 1957.

There are, however, a number of factors which will determine the design of the line, and thus directly or indirectly affect productivity and product cost. Many of these originate very early in the development program. Among these factors are: (1) Design of unit, (2) design of propellant manufacturing process, (3) safety requirements, (4) raw materials, (5) process and product specifications and (6) quality control procedures.

Illustrates These Points

The M-15 JATO, in production by Phillips Petroleum Co. at Air Force Plant 66, McGregor, Tex., since early 1956, provides an interesting illustration of these points.

The M-15 employs an extruded, inside-outside burning, cylindrical charge, supported between steel end-plates bonded to the grain through a rubber

restrictor. The pressure vessel is a conventional rolled and welded steel shell with a carbon steel nozzle. The aft head of the shell is fitted with two pressed-in safety disks, while the forward head is fitted with a full diameter closure retained by a strip key. Forward closure is a machined steel forging fitted with a threaded opening to receive the igniter. The hardware was designed to take maximum advantage of conventional, low-cost metal fabricating techniques, and to require a minimum of labor in assembly.

The propellant manufacturing process is quite simple, and bears a close resemblance to techniques widely used in the manufacture of compounded rubber materials. A simplified block flow diagram, showing the basic process elements involved, is shown on page 44. Work center locations in the production line conform to the process elements shown in the blocks.

Although a considerable amount of conventional explosive plant layout is evident at AF Plant 66—in part the result of taking advantage of existing structures—there is conformance to the traditional principles of continuity of operations and orderly flow from the initial stages of raw material entry to the discharge of the completed, crated units.

An idea of the approach employed in the design of facilities so as to accomplish maximum effective utilization of these principles may be obtained from the photograph on page 42. The photo shows the control panel for the mixing, blocking and extruding operations, all of which are carried out in one process building, and also demonstrates graphically the extent to which control instrumentation has been used in the plant.

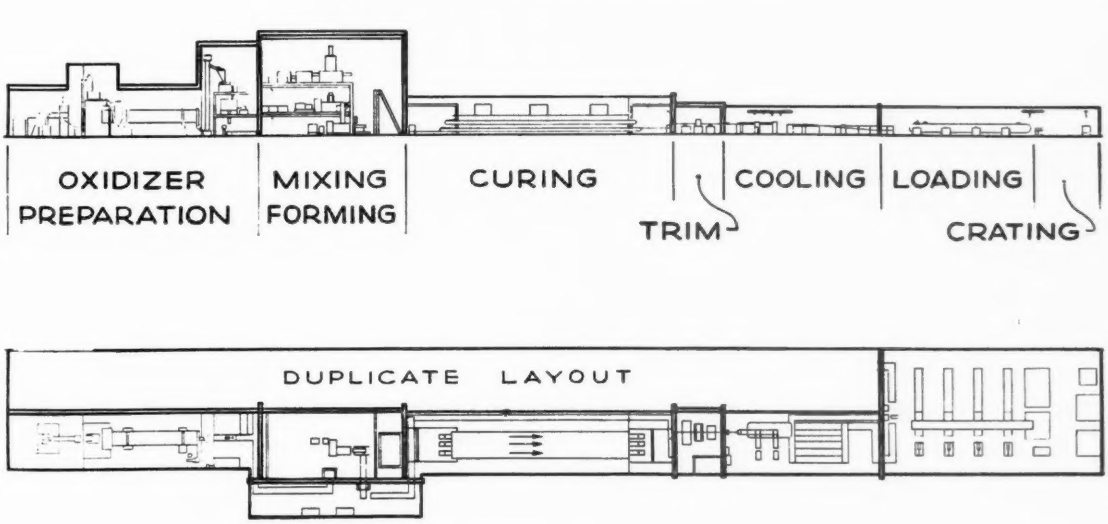
The problem of achieving safe operation while adhering to concepts of efficient production line layout is faced quite early in production planning. The solution may have a profound effect on productivity and costs. In the final analysis, production costs will reflect any nonconformance to such proven objectives as: (1) Compactness for ease of supervision, (2) close sequencing of operations to reduce transport time and distance, (3) providing appropriate "in-line" search or bank areas for in-process storage when required and (4) grouping of machines so that intermittent operation can be carried on by fewer workers.

Determined by Material Being Handled

In the case of the M-15, an approach was taken which may be unique in the annals of the ordnance industry. Safety precautions designed into the line and operating procedures applied were determined by the nature of the material being handled. Extensive explosive classification tests on the M-15 propellant and JATO showed that the hazard involved in production was only one of fire, unless the material was well confined. This finding has been substantiated in production experience, and has resulted in the elimination of the expense of conductive flooring in the process areas, conductive shoes for all workers, coveralls and other protective clothing with all of its attendant cleaning, storing, issuing and accounting expenses.

Some compromise in the full realization of the advantages of this approach was dictated by other considerations. The location of previous structures, and the desire to minimize facility costs by utilizing these structures in the new plant, resulted in a

Layout for Rocket Motor Production Line



greater dispersal of certain process elements than is considered necessary or desirable. Within the buildings, however, substantially full advantage was taken of the latitudes conferred by this approach to explosive safety. Convenient bank areas for in-process materials and components were established, making possible substantial savings in operating expense by eliminating the numerous instances when propellant and assemblies would otherwise require removal from the line in order to meet quantity/distance requirements.

The drawing on page 43 shows an ideal production line which takes maximum advantage of the principle of "safety with efficiency." This line is representative of a layout which conforms quite closely to the basic principles of compactness, close sequencing, convenient banks and machine grouping, while providing adequately for safety. Although described as an "ideal" design, it is nonetheless an eminently practical approach to the processing of propellant of the type used in the M-15.

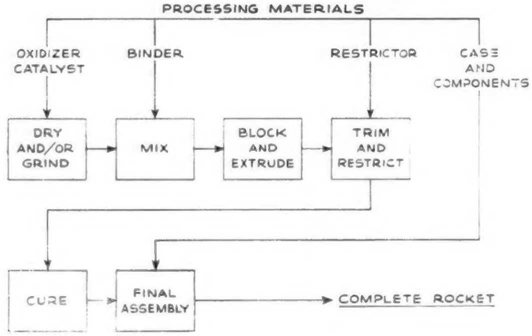
While its effect on the final cost of a solid propellant rocket is relatively small, choice of raw materials for the propellant is worthy of careful consideration in the development stage. More important, perhaps, than cost is the matter of universal availability of the raw materials in time of emergency as well as in time of peace. The M-15 adequately meets both these standards. A list of the raw materials used in the propellant and their current prices is shown above. Used in their respective quantities, they represent a total raw material cost of approximately 15 cents per pound of finished propellant. All are articles of commerce, domestically available, thus affording a broad base of supply without special Government support in time of peace.

In 1956, the production of ammonium nitrate in the U. S. was approximately 1.25 million short tons, and that of synthetic rubber approximately 2.5 million short tons. Since these two materials account for over 95 per cent of the weight of the propellant, it is apparent that the propellant is characterized not only by wide availability, but also by a broad market where competitive pricing can hold material costs in line.

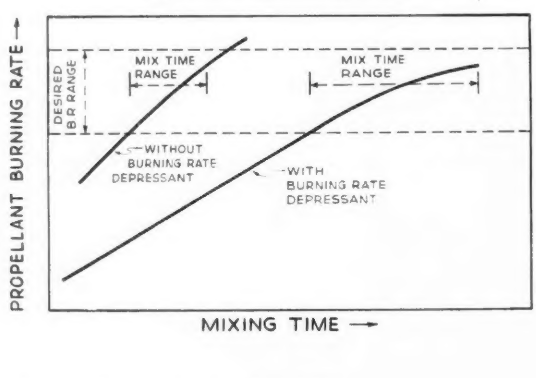
Propellant for M-15 JATO

INGREDIENT	PURPOSE	COST (cents/lb)
Ammonium nitrate	Oxidizer	3½
Synthetic rubber	Fuel and binder body	65
Carbon black	Reinforcing agent	6
Fleximine	Rubber antioxidant	76
Catalyst	Burning improvement	50
Additives	Plasticizing & curing agents	Avg. 45

Flow Chart for CPN Propellant



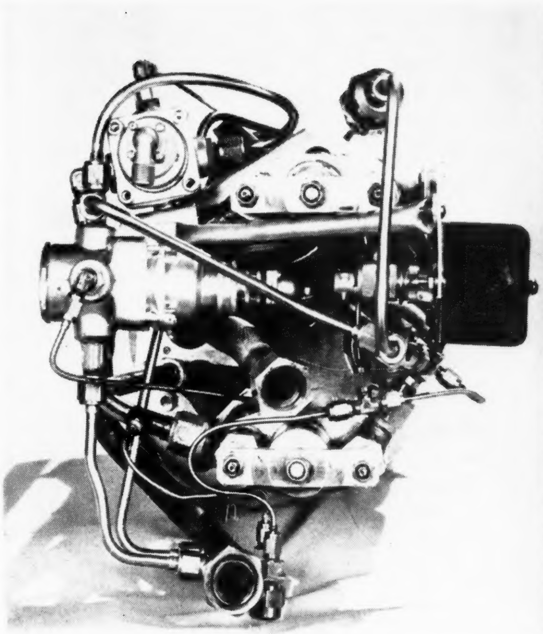
Effect of Mixing Time on Propellant Burning Rate



Specifications and Quality Control

A factor of great importance to ultimate production costs, often not appreciated sufficiently early in production planning, is the effect of process and products specifications and quality control procedures. These must be sufficiently firm by the time initial production operations are undertaken to assure that the product will meet requirements, and should be sufficiently definitive to permit the all-important factor of quality to be evaluated with at least some form of yardstick. The yardstick must, however, be recalibrated from time to time, using the results of production and field experience.

The initial process specification on the M-15 propellant, for example, called for control of the carbon black content of the binder mix to a range of ±5.7 per cent of the weight (CONTINUED ON PAGE 78)



Front (left) and rear views of LR6-RM-2 rocket engine used in the Lark missile.

Finally—Lark engine details

Liquid rocket powerplant slated for use on early Navy surface-to-air missile marked first departure from V-2 design concept

THE Navy Department's Bureau of Aeronautics has released details on the LR6-RM-2 liquid rocket engine which powered the Lark surface-to-air missile. The first complete rundown on the engine was given by Commander Robert C. Truax in a paper presented at the AMERICAN ROCKET SOCIETY's Semi-Annual Meeting in San Francisco.

The engine has a number of unusual engineering features, including a turbine powered directly by the propulsive jet of one of its two regeneratively cooled thrust cylinders. Truax noted in his paper that the engine represents the first radical departure, systemwise, from the design concept of the V-2.

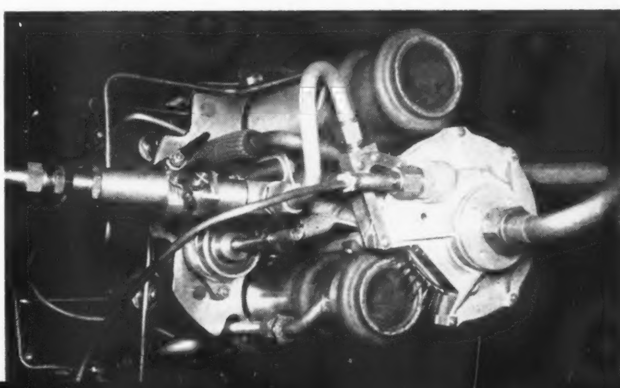
Use of a relatively simple turbine spun by the rocket exhaust to pump aniline and nitric acid allowed project engineers to combine the simplicity of a pressurized tank feed system with the low tank weight of a turbopump system, which normally requires an auxiliary source of gas for driving the turbine.

The LR6 was developed (CONTINUED ON PAGE 68)

LR6-RM-2 Rocket Engine Specifications

Rated thrust (lb)	200 and 600 (two-level)
Duration	Tank dependent
Specific impulse (sec)	>190
Combustion chamber pressure (psia)	315
Required suction pressure (psia)	30
Engine weight (lb)	40
Length (in.)	27

Model of liquid rocket engine on test stand.



ASTRONAUTICS Report—Part Two

Engineering for the high temperature age of flight

Analysis of present test techniques and materials reveals need for new type of engineering technology to solve many problems that still exist

By Frederick L. Bagby and Associates

BATTELLE MEMORIAL INSTITUTE, COLUMBUS, OHIO

TOWARD THE FUTURE

Last month, in the first part of this full-scale study of the high temperature flight problem, the authors explored the nature and scope of the difficulties high speed aircraft and missiles will encounter in the "thermal thicket." In so doing, they discussed some typical high temperature environments likely to be met by various types of vehicles, operating temperatures of present and future propulsion systems, and aerodynamic heating.

This month, they turn their attention to present high temperature test techniques and materials, covering metals and alloys, ceramics and cermets, and plastics and rubbers.

Their analysis reveals that many high temperature problems are still a long way from being solved. As the authors point out, development of a new type of engineering technology is essential to get the job done. Close cooperation between the chemist, physicist, metallurgist and the aeronautical or missile engineer and designer is necessary to solve many of the problems that now exist or can be anticipated.

This new concept of technology is still in its infancy, but results are already apparent. New materials, new techniques are forthcoming almost daily. Its full potential, however, can scarcely be estimated.

ELEMENTS involved in the high temperature engineering problem represent a degree of complexity seldom encountered in modern day technology. And increased complexity generally means increased uncertainty in the detail engineering of components and systems. This, in turn, leads to heavy reliance on experimental methods to assure that desired design objectives are achieved.

Although research is gradually reducing unknown areas of high temperature environments, much still remains to be determined. High temperatures and high rates of heat transfer, the possibility of chemical surface reactions and complex stress patterns, all occurring simultaneously, represent service conditions difficult to duplicate in the laboratory. Laboratory studies frequently involve modeling procedures, a technique not always applicable for the study of the response of materials to thermal environments because properties such as specific heat and coefficients of expansion are constants.

Instrumentation Is Always a Problem

Another limitation to laboratory studies is the always present problem of instrumentation. Some of the temperatures and transient conditions involved cannot be measured with the usual types of instruments. Full-scale operational testing thus remains the only completely positive means of evaluating designs, and for determining the exact nature of the high temperature environments of interest. Unfortunately, full-scale testing also represents a slow and costly procedure for obtaining technical data, especially when flight testing is involved.

Evaluation of materials for high temperature service requires simulation of at least four environmental conditions: Temperature, rate of heat transfer, chemical conditions at the surface and imposed forces such as viscous shearing forces in a boundary layer. Among the high temperature testing devices in use or contemplated for

investigating the reaction of materials to one or more of those conditions are:

Solar Furnace. Can provide temperatures up to 6000 F and heat fluxes approaching 2000 Btu/ft^2 sec. It is useful for studying small material samples where heat flux and surface emissivity characteristics are of primary interest, but is not adaptable to tests requiring high velocity gas flows.

Electric Resistance and Induction Heating. Can heat materials to melting points with ease and rapidity, but does not simulate conditions where material is heated from an external source, such as high temperature gas flows.

Rocket Combustors. Service conditions in combustor and nozzle of all types of operational rockets can be simulated closely in small-scale units. Also, throat areas of rocket nozzles are adaptable for simulating erosion and oxidation conditions for materials intended to withstand aerodynamic heating rates up to and exceeding 3000 Btu/ft^2 sec. Heating rates can be varied to simulate variations in aerodynamic heating rates of flight vehicles having specified mission profiles.

Combustion Jets and Tunnels. Useful for testing materials in high temperature, high velocity gas streams. While it provides lower heat fluxes than those obtainable in a rocket combustor throat, it can simulate oxidation environments of free flight. Specific heat ratio of air can be simulated at any given temperature.

Electric Arcs. Show promise as a dynamic high temperature testing device. Temperatures of over 10,000 F are obtainable with high heat fluxes. However, they cannot simulate the chemical or gas velocity environment of aerodynamic heating conditions in their present stage of development.

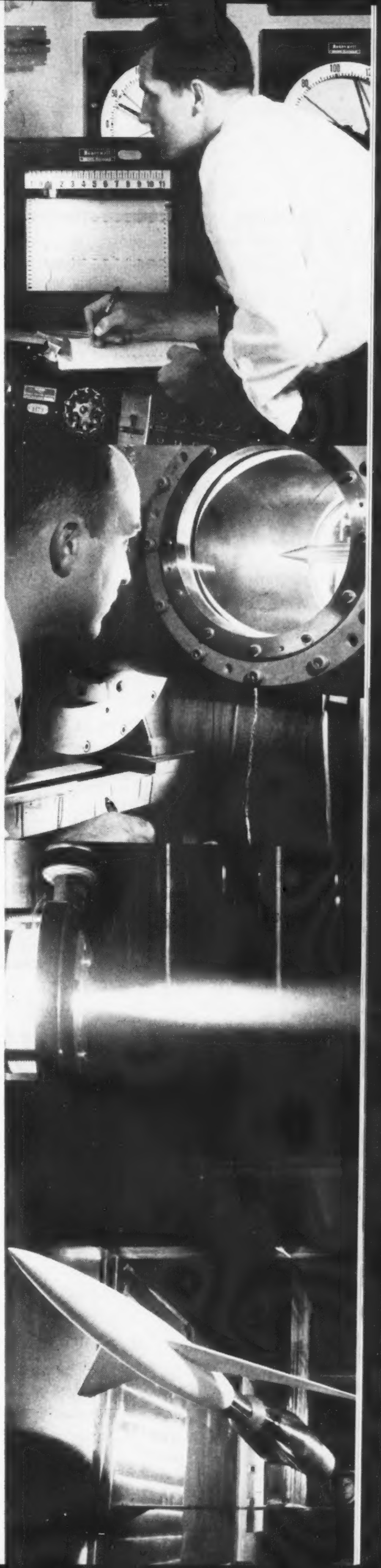
Plasma Jets. Provide extremely high temperature flows of ionized gases. Heat fluxes of at least 2000 Btu/ft^2 sec can be obtained, and temperatures of over 20,000 F are theoretically obtainable. Jets are limited for aerodynamic heating studies in the present state of development because of the low kinetic energy of the discharge gas flow.

Shock Tubes and Tunnels. Can simulate hypersonic gas flows, including temperatures and chemical characteristics, very closely. Their deficiency from the standpoint of material testing is the extremely short duration of test periods, which last only microseconds. Also, instrumentation requirements are extremely difficult to meet.

Electromagnetic Accelerators. Small material test specimens can be suspended in an electric field within a tube containing air or other gases. Accelerated through the long tube, a particle can reach hypersonic velocities. Accelerators provide close approximation to free-flight conditions, but considerable development is required to make such devices practical for material studies.

Pressurized Ballistic Ranges. Free-flight conditions and Reynolds numbers can be simulated exactly by firing projectiles from special hypervelocity guns down a pressurized ballistic range. Adaptability to material studies is limited.

Heated Air Jets. Ceramic storage bed heaters provide pressurized air jets with temperatures as high as 4000 F. This device is useful for studying material properties in high temperature air, although heat fluxes are moderate.



Wind Tunnels. Most expensive of all test facilities, the wind tunnel is the only type that can simulate free flight closely. Large hypersonic blowdown tunnels, using ultra-high temperature preheated air and capable of simulating temperature and velocity variations of a vehicle flight profile, appear feasible.

Brief mention must be made of a special high temperature testing situation. This is the use of atomic fireballs as high intensity heat sources. Such research has been carried out, and should provide a unique insight into material properties under the peculiar transient conditions of an atomic blast.

New Measuring Technique Needed

As previously mentioned, measurement of temperatures is a problem common to all types of high temperature research. Thermocouples and radiation pyrometers are suitable for measuring material temperatures in many situations. But thermocouples are limited to temperatures under 3000 F. Another technique is needed when higher temperatures are involved.

The use of radiation pyrometers is acceptable where geometrical considerations of the test setups do not handicap use of the technique. Spectroscopic methods can be used with good accuracy to measure temperatures above 3000 F, but the technique is cumbersome, and extensive calibration procedures are required. A calorimeter technique, where a high temperature gas sample is mixed with a known low temperature sample, serves well in many conditions.

The list of devices for high temperature, high velocity gas flow research is lengthy. Most of the devices, however, are unable to simulate exactly all aerodynamic heating conditions. Even wind tunnels and shock tubes are limited in their adaptability to the study of rarefied gas dynamics problems typical of ultra-high-altitude flight.

Properties Need Careful Study

In the final analysis, material properties will play a major role in the era of high temperature aeronautical engineering. A thorough understanding of the characteristics and limitations of a wide variety of materials will be required on the part of engineers if they are to achieve reliable, lightweight powerplants and airframes. Ingenuity and skill in exploiting particular characteristics of a material will be extremely important. Where material properties, such as melting points, are fixed, the problem

HIGH TEMPERATURE MATERIALS FOR

Metals and Alloys

Type of Material	Temperature Range
Aluminum alloys	
7075 T6	<250 F
2024 T4	<300 F
Magnesium alloys	
HZ32, EZ33, EK41	<500 F
HK31, HM31	<600 F
Titanium alloys	
6Al-4V	<700 F
7Al-3Mo	<700 F
5Al-2.5Sn	<800 F
Stainless steels	
Precipitation hardening	<700 F
Martensitic	Up to 900–1100 F
Austenitic	Up to 1200–1400 F
High strength steels	
AISI 4130 and modified 4000 series	<400 F
Die and tool steels	<1100 F
High temperature alloys	
Wrought nickel base, Cast nickel base	<1600 F
Wrought cobalt base, Cast cobalt base	<1650 F
Molybdenum	<2200 F
Special purpose metals	
Chromium alloys	<2000 F
Beryllium	Up to 1500 F without protective coating
Columbium	
	(see applications)
Tantalum	
Tungsten	
Copper	<1900 F
Metallic Protective Coatings	
Aluminum	<1800 F
Chromium	<1200 F
Nickel	<1200 F
Diffused Cr and Ni layers	(See comments)
Cobalt tungsten alloys	<2000 F
Nickel tungsten alloys	<2000 F

Ceramics and Cermets

Type of Material	Temperature Range
Crystalline Ceramics	
Conventional porcelains	<2200 F
Highly crystalline porcelains	2200+ F
Ceramic oxides	<4500 F
Graphite	<6000 F
Reduced ceramics	<7000 F
Amorphous or Glassy Ceramics	
Vitreous enamels	<1500 F
Glass-bonded ceramics	<1500 F
High silica, low-expansion glasses	1500 to 2200 F
Fused silica	2000 to 3000 F
Cermets	
Metal-bonded ceramics	1400 to 2700 F

AERONAUTICAL APPLICATIONS

Applications	Manufacturing Processes and Availability	Comments and Limitations
General airframe structure General airframe structure	Available as sheet, forgings, extrusions Available as sheet, forgings, extrusions	Little chance of increasing temperature range except in special case of sintered aluminum powders
Wheels, miscellaneous parts General airframe structure	Available as castings Available as sheet, forgings, extrusions	New alloys may be satisfactory up to 800 F
General airframe and engine structure General airframe and engine structure General airframe and engine structure	Available as sheet, forgings, bar Available as sheet, forgings, bar Available as sheet, forgings, bar	Titanium presently in development stage; future alloys may be useful up to temperatures of 1200 F
Airframe skins and structure	Available as sheet and plate	Future alloys may be useful to 900 F
Airframe structure	Available as sheet and plate	Future alloys may be useful to 1200 F
Power plant structure and components	Available as sheet and plate	Development to 1500 appears as limit
Fittings, machine elements	Available as plate, bar, forgings, castings	Future alloys may be useful to 700 F
Fittings, machine elements	Available as plate, bar, forgings, castings	Future alloys may be useful to 1400 F
Combustion liners, turbine blades	Available as sheet, forgings, castings	May be useful to 1800 F
Combustion liners, turbine blades, airframe structure	Available as sheet, forgings, castings	May be useful to 1800 F
Combustion liners, turbine blades, airframe structure	Available as plate, bar, and sheet	Subject to rapid oxidation; no commercial protective coatings available
Engines and airframes	Experimental alloys not commercially available	Lack room-temperature ductility; no coatings required
General airframe structure	In laboratory development stage only	Raw materials extremely expensive
These metals in alloy form all show promise for general structural application in the temperature range above 2000 F	Has been fabricated as bar, rod, slab, and strip; raw material reserves improved in recent years	Development just beginning; requires protective coatings
	In development stage	Requires protective coatings
	In development stage	May ultimately be usable at over 3000 F; requires protective coatings
Heat sink structures	Available in any form	
Coating of gas turbine buckets	Applied as a thin, diffused coating	
Protection of oxidizing metals	Electro or vapor deposit	Resists erosion and oxidation
Protection of oxidizing metals	Electro or vapor deposit	Resists erosion and oxidation
Protection of oxidizing metals	Electroplated coating	Excellent oxidation resistance; 1000 hr at 1800 F; 500 hr at 2000 F; 100–200 hr at 2400 F
Protection of molybdenum Protection of molybdenum	Electroplated coating Electroplated coating	High hardness and good oxidation resistance in slightly oxidizing atmospheres
Protective coating on metals	Sintered shapes	Generally have lower strength than oxides but are cheaper to produce
Protective coating on metals	Sintered shapes	Use less binder and are more refractory than conventional porcelains
Protective coatings and thermal insulation of high temperature structures	Sintered shapes, extrusions, flame-sprayed coatings, preformed shapes, moldings	Classification includes oxides of zirconium, aluminum, magnesium, etc.; may be useful as ablation-type coatings
Structural shapes	Molded or extruded shapes subsequently baked, machinable	Strength increases with temperature to about 4600 F; promising structural material if protected from oxidation
Structural shapes	Bonded or sintered shapes, hot pressings	Classification includes carbides, borides, nitrides, etc., all subject to oxidation; SiC is best and cheapest where resistance to high temperature oxidation is required
Protective coatings Radomes, structural shapes Radomes Radomes, windows	Spray coatings Preformed shapes Preformed shapes Moldings	These glass-bonded ceramic materials are limited primarily by the softening temperature of the binder used
Protective coating, turbine blades, valves	Powder techniques, sintered shapes	Brittleness intermediate between metals and ceramics; may extend temperature range of superalloys; many require protection from oxidation

(CHART CONTINUED ON FOLLOWING PAGE)

is mainly one of learning to live within the basic physical limitations of a given material.

The standard materials ranging from aluminum alloys through high temperature alloys continue to be important (see page 48), with increased interest now being shown in the properties of these materials over their entire temperature range. New structural forms of some of these materials, such as sandwich construction, are arousing interest because of advantages offered under certain high temperature conditions.

Development Is Under Way

Significantly, there is a growing interest in previously neglected metals and in metallic protective coatings. Alloys of columbium, tantalum and tungsten show promise for the temperature range just above 2000 F, but must be protected against oxidation. Intensive development of many of these new materials and coatings is just beginning.

Ceramics and cermets show promise as structural materials with working temperatures considerably higher than those possible with metals. The crystalline ceramics hold promise both as structural materials and as insulative or ablation coatings for the intense heating conditions experienced by reentry bodies. Amorphous or glassy ceramics appear to have logical applications as radomes and transparencies when plastics prove inadequate. Cermets are the transition between metals and ceramics with brittleness limitations.

Improvement Appears Likely

Although used in small quantities, rubbers and plastics represent a limiting factor on high temperature progress. Substantial improvement in the working temperature levels of some of the plastic and rubber materials appears likely, however, particularly if fundamental data are obtained on the oxidation characteristics of these materials. In this category of materials, the short-time, high temperature exposure characteristics are substantially better than the long-time exposure characteristics. And despite their temperature characteristics, plastics do have potential value as insulation and as ablating coatings for resistance to intense aerodynamic heating.

A look at the future of high temperature technology as related to the field of aeronautics reveals the vital need for a new type of engineering technology. The aeronautical engineer can no longer get by on a nodding acquaintance with science. Instead, the chemist, physicist, metallurgist and engineer will have to work together intimately to solve the high temperature problems that now exist, as well as those that can be foreseen.

Research in this area is moving at a rapid pace; and some results, in terms of new material concepts, are now becoming apparent. One example is the substitution of metals for carbon in polymers, giving rise to a family of organo-metallic compounds potentially capable of withstanding much higher temperatures than present fluids, rubbers and plastics. Another example is metal laminates made of layers of different metals using powder metallurgy techniques, and ultimately worked into forms and

HIGH TEMPERATURE MATERIALS

(CONTINUED)

Plastics and Rubbers

Type of Material	Temperature Range
Plastics	
Thermoplastics	
Polyacrylics	Up to 215–275 F
Polyamides (Nylon)	Up to 325 F
Polyethylene	Up to 170–250 F (depending on type)
Polystyrene	Up to 180–225 F (depending on type)
Polyvinylchloride	Up to 125–150 F
Fluoro carbons (Teflon, Kel F)	Up to 450–550 F
Thermosetting	
Amino plastics	275–400 F
Epoxy	250–300 F for long time service, up to 1000F for short time exposure
Polyesters-polyurethanes	400–500 F for long time service
Phenolics	250–350 F for long time service, up to 1000 F for short time service
Silicones	−90 to 480 F, up to 1000 F for short time exposure
Elastomers	
General purpose	
Natural rubber	
GR-S	−65 to 200 F, (350 F for very short service)
Polybutadiene rubber	
Butyl rubber	
Oil- and fuel-resistant rubber	
Nitrile	−65 to 250 F for extended use
Neoprene	350 F for short service
High-temperature rubbers	
Fluoro carbons	−50 to 450 F extended service to 600 F for short service
Silicones	−100 to 500 F extended service (800 F for short service)
Polyacrylates	−50 to 350 F for extended service, 400–450 F for short service
Other special purpose types	
Hypalon	Up to 300 F
Polyurethanes	200–250 F

Applications	Manufacturing Processes and Availability	Comments and Limitations
Windows, canopies, dials, luminated panels	Parts fabricated by injection molding or extrusion; availability good	—
Gears, bearings, cams, bushings, coatings for metal parts, fibers	Injection molding; availability good	—
Cable insulation, pipe, valves	Injection molding or extrusion; availability good	—
Housings, containers, insulation (foam)	Injection molding or extrusion; availability good	—
Pipe, cable insulation, tubing	Injection molding or extrusion; availability good	—
Electrical insulation, seals, gaskets, hose, high temperature applications	Injection molding and extrusion; availability good but expensive	—
Electrical outlets, housings, heat-resistant knobs, handles	Molding, impregnating; availability good	—
Electrical components, aircraft structural parts, wing sections (reinforced with glass fiber) high temperature adhesives for fabricating honeycomb and other aircraft structures	Molding, casting, laminating; availability good	New catalyst systems for improved high temperature use are under development
Radomes, high strength structural parts (same as for epoxy)	Casting, impregnating; availability good for polyesters, fair for polyurethanes	Development for high strength-high temperature use
Laminates and asbestos-filled gaskets for high temperature service, stabilizers	Laminating, molding; availability good	—
High temperature insulating varnishes, ozone-resistant coatings, gaskets, seals	Laminating, coatings; availability fair (high price)	Rapid curing of resins
Tires, insulation and miscellaneous noncritical parts	Extrusion, compression molding; availability good	Synthetic "natural" rubber
Tires, insulation	—	—
Tires, insulation	—	High temperature
Tires, tubes, insulation	—	Butyl tires
Gaskets, seals, hose	Extrusion, compression molding; availability good	Improved oil-resistant types
Gaskets, seals, hose	—	—
Fuel-resistant gaskets and seals, chemical resistance for peroxides, nitric acid	—	Improved types having higher tensile properties
Seals, low and high temperature gaskets, insulation	—	—
Seals, gaskets	Extrusion, compression molding; availability poor	—
Ozone resistance	Availability fair	—
High abrasion resistance	Molding, casting; availability poor	Oil-, fuel-, and high temperature-resistance

shapes in a manner similar to current metal-working techniques.

Finally, basic research into the physics of the solid state promises to provide ways of improving properties of materials at all temperatures. Understanding of the ways in which atoms arrange themselves in crystals and of how to control these arrangements may provide answers to the present inconsistencies in material properties. Such knowledge can also pave the way for the development of custom-made materials. Cermets and materials compounded of rubber and plastic are the first attempts to develop materials of mixed characteristics.

But this new concept of materials technology is still in its early stages. Its full potential, far from fulfillment, can scarcely be estimated at present.

It is already providing us with new materials and new techniques which help us come closer to a solution of many of the problems associated with the high temperature environments that will be encountered by tomorrow's vehicles.

There can be little doubt that further development of this new kind of engineering technology will in the not too distant future provide us with components and systems for vehicles with high temperature capabilities well beyond those that exist today.

Why not astronautical engineers?

Addition of new curriculum to those already offered by engineering colleges would make more trained men available to missile industry

By John Gustavson

CONVAIR-ASTRONAUTICS, SAN DIEGO, CALIF.

A FLAME THAT NEEDS FANNING

It's doubtful if any subject evokes greater enthusiasm among the youth of this country today than space flight. To a generation bombarded during the last couple of years with literature about Project Vanguard, earth satellites and space flight, there is no more exciting or glamorous career to follow than that of a rocket or guided missile engineer.

However, youthful enthusiasms, like unfanned flames, often die, and the teen-ager who today dreams of the time when he will be an engineer working on the first manned space ship may tomorrow decide he'd rather become a doctor or a lawyer.

By failing to fan this enthusiasm, we are missing out on a golden opportunity to alleviate the growing shortage of engineers in our industry. Keeping this interest alive and assuring youths who want to study astronautical engineering that they can do so are only two steps toward the solution of the problem. Others should and must be taken. However, it is hoped that the author's suggestion of an astronautical engineering curriculum will generate some specific proposals for such a course by educators in the field.

John Gustavson's suggestions are based on practical experience gained while giving courses in astronautics. He has taught courses in astronomy and space flight in a municipal night school in Denmark and for the past two semesters has given a course in basic aspects of space flight at the University of California Extension at San Diego. Mr. Gustavson is now studying for his doctorate in mechanical engineering at the University of California while on leave of absence from his position as design engineer with Convair-Astronautics.

THE rapid growth of the missile industry and increasing interest in space flight have resulted in a new demand of our schools and universities. The multimillion-dollar missile industry employs tens of thousands of engineers, hired from the fields of aeronautical, civil, electrical, electronic, mechanical and chemical engineering. None of these engineers was familiar with missile systems before his initial employment by a missile firm, and many companies are still fighting hard to turn them into missile engineers.

Early signs of this new engineering demand appeared almost ten years ago, yet today, nearly a decade later, no educational institution in this country has admitted the specific study of missile engineering into its curriculum. Although the missile industry is the one most vital to our national defense, companies in this field must still scramble for and train their own engineers.

Closely related to the missile is the space vehicle, the means of transportation by which man, within a few decades perhaps, will escape from the earth and travel to other planets. The relationship between the missile and the space vehicle is similar to that which exists between the fighter plane of World War I and today's commercial airliner. The missile is, of course, vital to this country for the preservation of peace, and missile engineers are today primarily concerned with building better weapons systems. However, the missile has still another application—one which utilizes its components to open the door to the universe.

Concerned with Space Flight in His Daily Work

Thus any missile engineer is concerned either directly or indirectly with space flight in his daily work. His job designation, then, might well be "astronautical engineer."

The need for astronautical engineers is likely to grow, rather than diminish, in the foreseeable future. But where are they to come from? How will the need be filled? Exactly what kind of training should they have?

These are among the questions that still remain to be answered, and they are questions that must be answered if we are to build better missiles and continue to make progress along the road to space flight.

Meetings like this, sponsored by ARS Philadelphia Section, are of primary importance in generating interest among youngsters in careers in the rocket and guided missile industry.

"Get 'em young, train 'em right" has been the motto of many successful businesses, so perhaps the place to begin the search for future astronautical engineers is in the secondary schools. High school students, for example, might be extremely interested in introductory lectures on space flight, and could conceivably be influenced by such lectures in their choice of a vocation.

The average high school student is likely to be at loose ends when the time comes for him to select a course of study. In most instances, science departments must literally wage a battle for the interest and attention of the scientifically uninspired freshman. With the introduction of astronautics into high school curricula, science might get a much-needed shot in the arm. At present, few subjects can compete with astronautics in winning the interest of students. It may be assumed, then, that the introduction of astronautics into established natural science, geography and arithmetic courses might well promote scientific curiosity and interest.

Upon completion of high school, the academic student begins his search for an appropriate college or university. If by chance he wishes to attain an engineering degree, and specifies astronautics as his particular branch of study, he is out of luck. At present, not one educational institution offers a degree in astronautical engineering. The student is therefore left with a choice of many regular engineering schools, most of (CONTINUED ON PAGE 63)

High school students follow the author's description of the Vanguard vehicle.

missile market

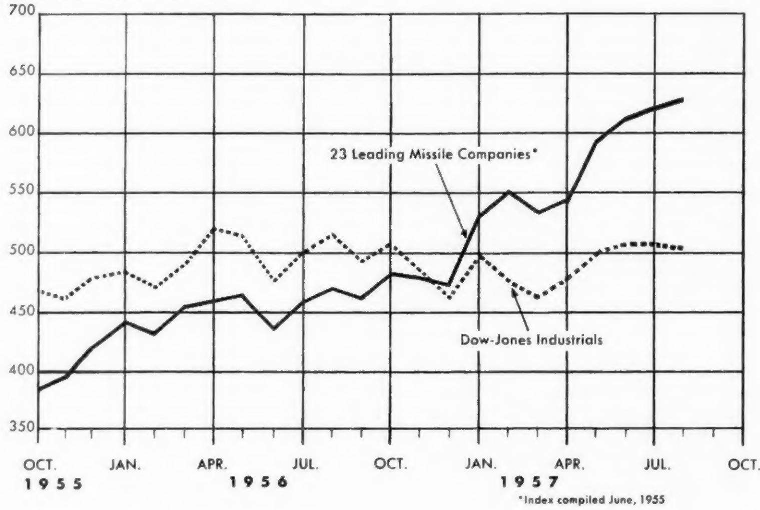
Financial news of the rocket and guided missile industry

BY ROBERT H. KENMORE

CROSS-CURRENTS within the industry keynoted market activity in the past month, with a resultant stand-off in stock averages. Aircraft stocks showed substantial declines as a result of the interim cloud thrown over the industry by government economy moves and the London disarmament talks. The highlight of the period, which brought home to investors what *can* happen in this industry, was the cancellation of North American's contract for the Navaho missile, which blew away the promise of a billion dollars in future contracts for the company had the missile gone into full production. On the other side of the coin were those companies more strictly concerned with guidance, engines and fuels for rockets and missiles, as a preponderance of bullish news helped accelerate the upward trend of their securities.

In so far as the aircrafts are concerned, the basic industry position still appears good. Military procurement will not slacken appreciably and backlog for most companies is enormous. The switch to missiles will accelerate, and most of the leaders in the industry are adequately prepared for the trend. Much of the budget noise from Washington is politics, and disarmament talks cover only a small part of the over-all arms picture.

THE MARKET AT A GLANCE



	August 1957	July 1957	% Change	August 1956	% Change
Dow-Jones Industrials	505	503	+0.4	521	−3.1
23 Missile Companies	628	621	+1.1	471	+33.3

Valuation Is a Question

A frequent dilemma facing investors in a bull market is the question of valuation. This is as true of companies in the rocket and guided missile field as it is for the general market. Posed in a specific way the problem reads: Given the accepted fact that securities prices are determined by earnings and dividends, if two blue chip companies earn \$3 a share and pay out \$1.50, and one sells at 30 and the other at 60, is the one at 30 automatically the best buy? The answer is a qualified "No," for the big variable in stock price valuation, and one of the hardest things to determine for a particular company, is its proper price-earnings ratio.

In this greatest of all bull markets, many investors, refusing to pay a fancy price for unseasoned securities, have over the past few years built up portfolios of high quality, good-yielding blue chips, and have seen them do absolutely nothing during this period. Meanwhile, "overpriced" growth companies, paying out little of their big earnings, have continued to go up, up, up. This is not to say that speculative securities have outperformed quality stocks, but rather that the leaders in glamorous growth industries are now selling at 30 to 40 times earnings, while their less spectacular neighbors in long-established fields are hard put to command a valuation amounting to eight or 10 times earnings.

For five years I have followed a small electronics company with interest. It looked overpriced five years ago, it has looked overpriced throughout this five-year period and it still looks overpriced now. Nevertheless, the stock is now selling at exactly 20 times what it sold for five years ago, and, while earnings have unquestionably improved during this period, the real factor in the price increase has been the changing valuation of these earnings by investors: From eight to 40 times. Yields are no help or criterion in selecting investments either, since this company, as an example, paid \$0.25 cash per year five years ago, and still does.

The whole point is that in this market nothing seems to succeed like success. An additional factor is that both institutional and individual investors, once they have latched onto a successful investment, just lock it away in a box and refuse to sell it.

It looks as though the biggest continuing problem which any company in the rocket field will face in the near future will be its capability of raising sufficient money at reasonably advantageous rates to continue its expansion. That the whole economy is money-hungry is pretty obvious. On a given Wednesday of last month, the capital market was offered a whopping half a billion dollars worth of debt issues. It is equally apparent that the money market is not willing to supply this type of funds at anything but premium rates at the present time.

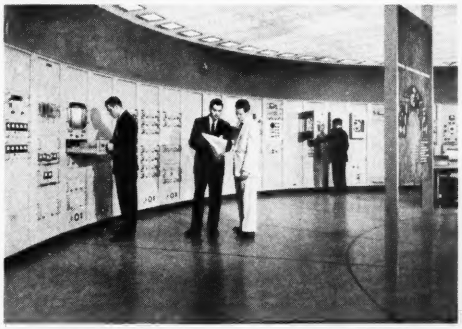
Seek Additional Funds

Some recent demands within the field: General Precision Equipment, \$10 million worth of \$3 cumulative convertible preference stock; Thompson Products, \$20 million in convertible subordinate debentures; Emerson Electric, \$3$^1/_2$ million worth of 5$^1/_2$ per cent convertible subordinate de-

(CONTINUED ON PAGE 84)

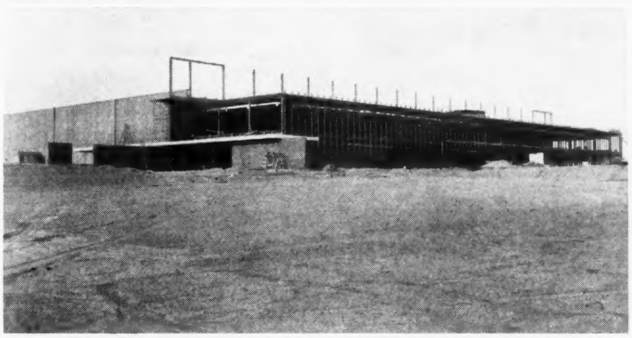
30-channel, analog-digital converter connecting 300-amplifier analog computer to 1103A digital computer

Production of communications equipment in new Los Angeles manufacturing plant

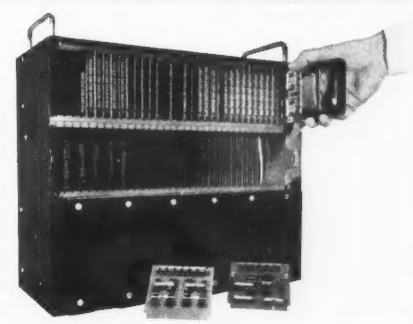


Data Reduction Center designed and built by Ramo-Wooldridge

One of three new research and development buildings completed this year



First unit of Denver manufacturing plant now nearing completion



Input-output unit of the Ramo-Wooldridge RW-30 airborne digital computer

Pictorial **PROGRESS REPORT**

The photographs above illustrate some of the recent developments at Ramo-Wooldridge, both in facilities and in products. Work is in progress on a wide variety of projects, and positions are available for scientists and engineers in the following fields of current activity:

- Communications and Navigation Systems
- Digital Computers and Control Systems
- Airborne Electronic and Control Systems
- Electronic Instrumentation and Test Equipment
- Guided Missile Research and Development
- Automation and Data Processing
- Basic Electronic and Aeronautical Research

The Ramo-Wooldridge Corporation

5730 ARBOR VITAE STREET • LOS ANGELES 45, CALIFORNIA

Successor to the Transistor

(CONTINUED FROM PAGE 34)

In essence, the Spacistor improves on the conventional transistor's rate of charge diffusion through the semiconductor block. It does so by increasing the field strength across the block, particularly through the base region, by creating a space-charge region through the use of reverse-biased junctions. The Spacistor consists of a simple p-n connection.

When operating, electrons are injected into the space-charge region. This current is modulated by another nearby contact in the same space-charge region. The contact is a small alloyed p-type, also biased in reverse to draw negligible current, thus permitting it to function analogous to the grid of a vacuum tube.

In the top drawing on page 34, I is the electron injector, M the modulator, B the base and C the collector. B and C are the output points. The space-charge region, exaggerated in size, is represented by sc. By connecting B to I through battery B_1, I is biased negatively with respect to the sc region. Electrons then flow into the region. Since M is also biased negatively with respect to sc (by means of battery B_2), the charge carrying "holes" cannot flow from P to sc, so M draws practically no current.

In the bottom drawing on page 34, a voltage is applied between the base and collector in such a direction as to produce a high electric field but virtually no current. Electrons enter the field through the injector, flowing very rapidly to the collector because of the field. This current, or flow of electrons, is modulated by the controlling signal piped in at the modulator contact. Because the modulator draws only negligible current while causing fluctuation in the current, amplification is the end result.

'Space Dogs' Get Hero Treatment in Soviet Press

THREE of the dogs used in the much-publicized Soviet experiments to determine effects of high altitudes and extremely fast acceleration on sentient beings have been given the full hero treatment in a recent article in the Russian press.

The anonymous author of the article, picturesquely entitled "The Attack on the Cosmos," provides a brief rundown on Soviet rocket experiments and then goes into considerable detail about the dog experiments, designed to pave the way for manned flights at altitudes of about 100 km and described in the February 1957 issue of JET PROPULSION.

The author tells how "three very lively and gay dogs," named Albina, Malyshka and Kozyavka, were selected for the experiments, trained and then sent on their first rocket flights. The dogs were carried in hermetically sealed containers in the nose of the rocket, which rose to altitudes of approximately 100 km.

At that point the container, about 0.29 cu meters in volume and containing a system for regeneration of air, was released and allowed to fall freely to about 3 km, where a parachute opened and floated the container back to earth. Blood pressure, pulse and temperature of the animals were measured during the flight, as well as air temperature and pressure in container.

SOVIET SPACE VETERANS. At left, Albina is fitted for a space suit. Top right, Malyshka gets a breather after testing the suit, and, above right, Albina seems perfectly at home during a prolonged test.

A physical examination of the dogs revealed no major damage, the author reports, and the success of the first attempts led to a second series of experiments. In these tests, the dogs were provided with simple space suits with transparent plastic helmets through which they could be photographed, and sent up in an open container.

The author describes how 12 dogs, including the ever-present Albina, Malyshka and Kozyavka, were trained for two months before the flights were made, with the final selection of seven dogs being made from the animals that appeared to be most comfortable and remained quiet for the longest periods in their space suits.

This time the dogs were ejected from the container one by one. At 90 km, Albina, now a space veteran, was catapulted out and allowed to fall freely for 3 seconds. At about 85 km, the parachute opened and Albina spent the next hour floating back to earth. The other dogs were allowed to fall freely within the rocket to lower altitudes, and then ejected one at a time at different heights. All returned safely to earth.

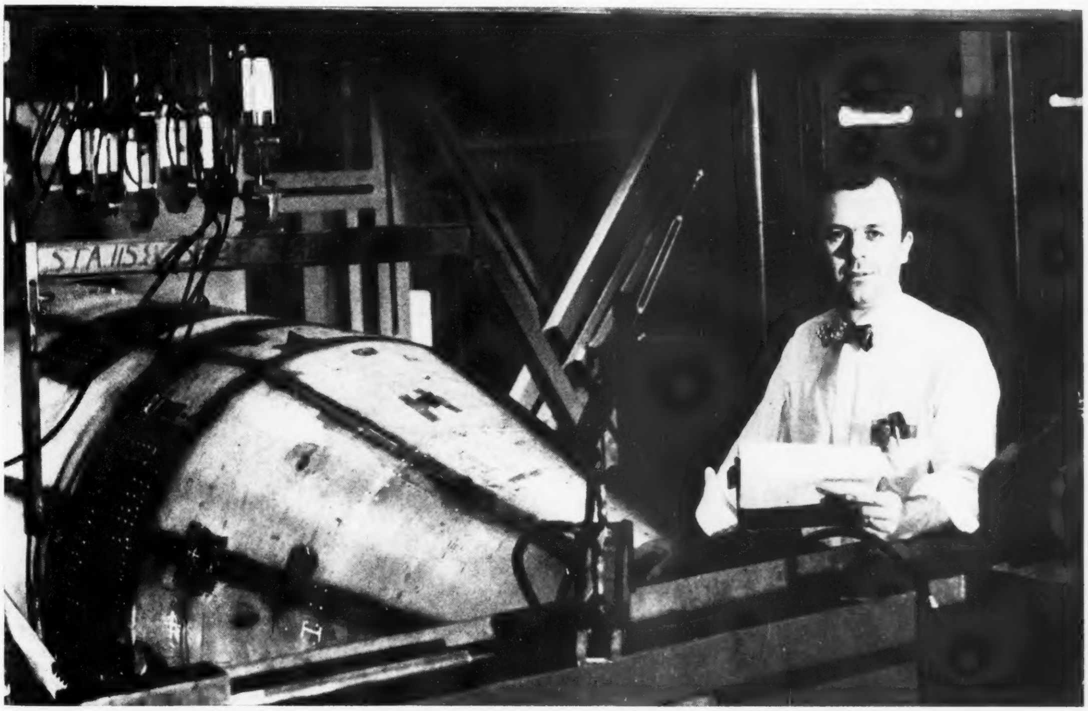
The Soviet scientists again found that the dogs' physical condition was satisfactory and that the space suits had functioned perfectly during the entire flight. Thus, the author concludes categorically, the experiments show that "the flight of people to the Cosmos is possible."

In introducing the subject of rocketry, the author tips his hat to K. E. Tziolkovski, described as the "founder of the new science of astronautics," and reveals that the Soviet Academy of Sciences, like many American organizations studying space flight problems, has also been swamped by letters from Russians who want to be the first to go to the moon or Mars.

THE FORWARD LOOK

From Trains – to Planes – to Missiles . .

DON DRESSELHOUSE MOVES UPWARD WITH CHRYSLER CORPORATION MISSILE OPERATIONS



When an industry is expanding, companies in that industry grow rapidly and opportunities in those companies multiply.

Such an industry is "Missilery"—a name so new that it can't be found in the dictionary. It is one of America's fastest-growing industries . . . loaded with opportunity for engineers of every type and job experience.

Take, for instance, the case of Don Dresselhouse. After graduation from Iowa State University in 1948, Don worked as a track engineer for a railway company and then as a senior stress engineer for an aircraft company. In search of greater opportunities, he joined Chrysler Corporation Missile Operations in 1956.

Today, at the age of thirty-one, Don has progressed rapidly and, as Managing Engineer of the Structural Laboratory, is contributing his ability and enthusiasm in helping solve some of the perplexing problems that make Missilery the exciting and challenging industry it has become.

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ARS news

Kaplan to Address ARS Student Conference

Joseph Kaplan, chairman of the U. S. National Committee for the International Geophysical Year, will be the principal speaker at a luncheon to be held during the AMERICAN ROCKET SOCIETY Regional Student Conference December 6–7.

Kurt Stehling, ARS National Program chairman, has also announced that a panel of scientists and engineers from the IGY program would face an audience of students during the conference and answer questions relative to IGY proceedings.

Mario Cardullo, chairman of the host committee from the Polytechnic Institute of Brooklyn ARS Chapter, announces that his committee has been augmented by the presidents of all of the ARS Student Chapters in the New York area. They are Robert E. Huber of New York University, Frank J. Ford of the Academy of Aeronautics, Richard E. Nelson of Stevens Institute of Technology, and Paul W. Cooper, of Brooklyn Poly.

The Conference will feature presentations of papers by students from colleges east of the Mississippi. The papers will cover subjects related to IGY—satellites, instrumentation, upper atmosphere research, sounding rockets, meteorology, geodesy, astrophysics, cosmic rays, etc.

Serving on the board of review for the papers are Robert A. Gross, president of the ARS New York Section and chief research engineer at Fairchild Engine Div., and the faculty advisors of the Student Chapters—T. Paul Torda of Brooklyn Poly, Michael Maccarone of NYU, Ralph Hautau of the Academy of Aeronautics, and Melvin Hausner of Stevens. The New York Section is sponsoring the publication of the proceedings of the conference.

Deadline Now Oct. 15

The deadline date for papers for the Conference, originally announced as Sept. 1, has been changed to Oct. 15. Papers should be submitted in duplicate and should be double-spaced on one side of paper only. There are no limitations on the length of the papers. All papers submitted will be considered for the ARS Chrysler Corp. Student Award of $1000.

Map Plans for Student Conference

Mario Cardullo of Brooklyn Poly (left) chairman of the host committee for the ARS Student Conference, discusses plans for the meeting with committee members Robert E. Huber of New York University (center) and Paul W. Cooper of Brooklyn Poly.

New members of the ARS Eastern Regional Student Conference Committee are (top, l to r) Robert E. Huber of New York University, Frank J. Ford of the Academy of Aeronautics and (below) Richard E. Nelson of Stevens Institute of Technology and Paul W. Cooper of Brooklyn Poly.

5 More Companies Become ARS Corporate Members

Five additional companies active in the rocket or jet propulsion fields have become corporate members of the AMERICAN ROCKET SOCIETY.

The new members are:

Propulsion Research Corp., Santa Monica, Calif., active in the liquid rocket, propellants and combustion, ramjet, solid rocket and space flight fields.

Representing the company in ARS activities are Rolf D. Buhler, staff assistant for research; Jerry Glaser, assistant manager, Accessories Div.; Charles A. McGregor, engineering supervisor; Francis C. Morris, senior engineer; and Lee R. Woodworth, head, preliminary design.

Hydro-Aire, Inc., a subsidiary of Crane Co., Burbank, Calif. The company has developed several accessories for missile applications, including fuel transfer pumps and valves. At present, Hydro-Aire has several products in the research and development stage with applications in the rocket field,

New positions in

MISSILE SYSTEMS PROPULSION

Weapon systems management activities at Lockheed's Palo Alto, Sunnyvale and Van Nuys organizations call for significant achievement in propulsion. Areas include design analysis, evaluation of test information and technical management of propulsion subcontractors. Inquiries are invited from those possessing a high order of systems ability and strong familiarity with solid and liquid propellant rockets and ramjets. Please address the Research and Development Staff, Palo Alto 35, California.

Here Propulsion Staff members discuss problems relating to accurate positioning of a vehicle in the upper atmosphere. Left to right: J. F. Houle, propellant feed systems analysis; B. Ellis, Propulsion Department manager; J. J. Donhan, control force generators.

Lockheed

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among them a group of accessories designed to handle exotic fuels, and extremely high temperature pneumatic accessories.

Designated as ARS representatives for the company are Roy C. Johnson, service engineer; D. B. Nickerson, chief engineer; Frank Cooper, vice-president and general sales manager; Dale A Lichty, president; and Ben Rappaport, project engineer.

Dean and Benson Research, Inc., Clifton, N. J., active in the development of blowers for missile cooling systems and oxygen valves.

Named to represent the company in ARS are George A. Dean, president; Joseph Micka, plant manager; Leo Avondoglio, chief research engineer; Richard C. Portofee, sales manager; and Herbert C. Gynan, chief design engineer.

Solar Aircraft Co., San Diego, Calif. Its activities include guided missile systems development and component development and manufacture; development and manufacture of auxiliary equipment for missiles; and the manufacture of rocket motors.

Representing the company in ARS are Sumner Alpert, chief technical engineer; William A. Knoll, project engineer; M. C. Towns Jr., chief propulsion engineer; Daniel H. Driscoll, senior propulsion engineer; and E. O. Naumann, chief of advanced studies.

Servomechanisms, Inc., Hawthorne, Calif. This company is active in the fields of servo controls for liquid rocket engines, special guided missile instrumentation, and special analog computer systems and subsystems, as well as automatic missile checkout and guidance alignment equipment.

Named to represent the company in the ARS are W. W. Shannon, president; Ralph Redemske, vice-president; Gordon Robinson, manager, customer services; Louis deBottari, chief, missile controls group; and Helmut Zoike, chief, missile engineering section.

Rocket-Satellite Exhibit Set for ARS Annual Meeting

The American Rocket Society is again sponsoring a series of exhibits in conjunction with its annual meeting in New York City Dec. 2–6. A special Rocket and Satellite Section has been established in the 26th Exposition of Chemical Industries, to be held concurrently with the meeting. The Exposition will be at the New York Coliseum, just a short distance from the Statler Hotel, headquarters for the ARS meeting.

The Rocket and Satellite Section will include exhibits by prime contractors for the government, as well as suppliers of equipment, components and materials.

Among the companies planning displays in the Section are:

Alco Products, Inc.; Allied Chemical & Dye Corp.; American Rocket Society; Arwood Precision Casting Corp.; Atlantic Research Corp.; Bendix Products Div.; Cambridge Corp.; Chrysler Corp. Missile Operations; Clary Corp.; The Dow Chemical Co.; T. R. Finn & Co. Aeronautical Div.; Becco Chemical Div. and Westvaco Chlor-Alkali Div. of Food Machinery & Chemical Co.; Missile and Ordnance Systems Department and Rocket Engine Section, General Electric Co.; Marman Products Co., Inc.; The Martin Co.; Missile Development Div. and Rocketdyne Div. of North American Aviation, Inc.; Reaction Motors, Inc.; Surprenant Mfg. Co.; and Thiokol Chemical Corp.

SECTION NOTES

Cleveland-Akron: Frederick C. Durant III, consultant for Arthur J. Little Co., and a former president of the American Rocket Society, was the guest speaker at a recent meeting of the Section at the General Electric Co.'s Evendale plant. Speaking on "After Project Vanguard, What?" Du-

Out of the Past

Some familiar faces are seen in this photograph taken during a visit to England by Robert C. Truax just 20 years ago. Truax, then an Annapolis Midshipman and now a Commander and ARS President, is third from right, with Eric Burgess second from left and Arthur C. Clarke at far right.

Hatching a Special Edition

Maj. Gen. W. E. Laidlaw, Commanding General, White Sands Proving Ground (left), George L. Meredith, president, New Mexico-West Texas Section (center) and William I. Latham, editor, *El Paso Times*, discussing plans for the *Times*' special edition on rockets and guided missiles.

rant reviewed the IGY earth satellite program and discussed the three-stage Vanguard launching vehicle from the standpoint of its contribution to astronautics.

Maryland: The last pre-summer meeting of the Maryland Section, held at the Thiokol Chemical Co. plant in Elkton, Md., and highlighted by rocket test firings, a tour of the plant and the announcement of new officers and directors for the coming year, was a rousing success. Thiokol fired two solid propellant rocket motors on a static test stand in a field near the plant for the group and then escorts took the 80 members and guests present on a complete plant tour. The cocktail hour after the tour put everyone in a holiday mood for the meeting which followed.

Samuel Fradin, Miller Research Laboratories, has been elected president of the Section for the coming year. Other new officers are: Walter J. Crotty Jr., Aero Engineering Co., vice-president; Mitchell Angelos, Aircraft Armaments, Inc., secretary; and Ralph Gray, Air Arm Div., Westinghouse Electric Corp., treasurer.

New directors are: Andrew W. McCourt, Westinghouse Air Arm Div.; George W. Lescher, Fairchild Engine & Airplane Corp.; Irwin R. Barr, Aircraft Armaments; Sears Williams, The Martin Co.; and Milton Rogers, AF Office of Scientific Research, ARDC.

New Mexico-West Texas: At a recent Section meeting, Mayo Seamon, advertising director of the *El Paso Times*, discussed plans for publication of a special rocket and guided missile edition of the *Times* and *El Paso Herald-Post* on Aug. 31 and Sept. 1. The edition, the brain-child of Seamon and Joseph Demic, *Times* staffer and ARS associate member, included material from White Sands Proving Ground, Holloman Air Development Center and Fort Bliss.

The Section had an advisory role in the publication of the edition, helping to obtain material and making sure it was technically correct.

Two color movies, "Signals for Missiles," telling the story of the White Sands Signal Agency, and "Proving Tomorrow's Weapons," depicting activities of the Ordnance mission, were shown at the regular meeting in Gardner Hall, New Mexico College A&M.

Pacific Northwest: "High Performance Solid Propellant Rocket Engines" was the topic selected by J. W. Wiggins, assistant technical director of the Redstone Div., Thiokol Chemical Corp., for his address before a recent meeting of the Section, held in the University of Washington's Health-Sciences building auditorium in Seattle.

San Diego: The Section's annual business meeting was held late in July. Members and guests enjoyed the cocktail hour and dinner, and afterwards heard retiring president Krafft A. Ehricke's report on the activities of the past year. After thanking the Section's board of directors, Ehricke turned the meeting over to the new president, William H. Dorrance, who

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Robert E. Huber, New York University
Gerald Chmielewski, Parks College of Aeronautical Technology
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J. B. Bullock, University of Michigan

New San Diego Section Board

New officers and directors of the San Diego Section are (left to right) Charles J. Swet, treasurer; John Gustavson, secretary; Elliott J. Katz, vice-president; William H. Dorrance, president; and Charles I. Ames and Krafft A. Ehricke, directors.

introduced the other new officers and directors.

They are Elliott J. Katz, vice-president; Charles J. Swet, treasurer; John Gustavson, secretary; and Charles I. Ames, Karel J. Bossart and Ehricke, directors. All are with Convair.

The meeting concluded with a showing of "Horizons Unlimited," a color film picturing the assembly and launching of the Viking research vehicle.

At the previous meeting, held jointly with the San Diego sections of the Institute of Aeronautical Sciences and the Instrument Society of America, J. Allen Hynek, associate director of the Smithsonian Astrophysical Observatory, Cambridge, Mass., and in charge of the Vanguard optical tracking program, was the guest speaker.

Dr. Hynek described the organization of the program and the approaches taken to some of the difficult photographic problems involved in it. The address was of special interest because he was on the final leg of a trip around the world to contact photographic tracking stations for the project.

Southern California: James H. Hedberg of Firestone Tire and Rubber Co. and P. I. Wood of Aerojet-General Corp., were the guest speakers at the August meeting of the Section, held at the Rodger Young Auditorium in Los Angeles.

Hedberg showed a movie depicting the development of the Corporal missile and illustrating the handling procedures involved in a typical tactical firing. Following the movie, he described construction details of the Corporal liquid propellant engine.

Characteristics of typical auxiliary power systems, including liquid monopropellant, liquid bipropellant and solid propellant systems, now under development at Aerojet were discussed by Wood. He pointed out that realization of the much-discussed possibilities of space flight would depend to a considerable degree on projects currently under way to provide auxiliary power for space vehicles.

Wichita: Flight to Jupiter and Saturn is theoretically possible with a combination of propulsion systems now being conceived, George P. Sutton, chief of preliminary design, Rocketdyne, and ARS national vice-president, told the Wichita Section at a recent meeting.

While cautioning that an evaluation of propulsion devices for space vehicles is "highly speculative" at this time, Sutton said that present liquid propellant engines may well be adequate for take-off and landing on earth and nearby planets, and that the refinement of present powerplants will make a notable contribution to space flight. He noted, however, that even by extending present propulsion methods, a trip to Mars and back would take about $3^1/_2$ years.

In considering future propulsion systems, he said that atomic rockets might greatly increase specific impulse and that successful storage of free radicals might make possible other improvements in performance. In outer space, he added, energy sources such as solar heating or ion propulsion systems might provide low thrust for substantial periods of time.

Solid Fuel Molecules Weighing 1000 lb Reported

As part of the present push for solid propellants, intense research is under way to get the propellant molecules as long and cross-linked as possible. Smoother combustion results from such molecules.

A significant step along these lines has been made at the U. S. Naval Ordnance Test Station at China Lake, Calif., it has been learned. Under the direction of A. T. Camp, the propellants division is "cross-linking nitrocellulose molecules to one another and to a new high energy plasticizer through the use of fairly common chemicals." The resulting structure is relatively insoluble, and therefore has an essentially indeterminate molecular weight, according to Dr. Camp.

In these circumstances, an entire batch of fuel might be considered as one molecule, much like a tire might be thought to be a single molecule after vulcanization. A molecule weighing 1000 lb would thus be conceivable, and such a monster reportedly has been achieved at NOTS.

The nitrocellulose-plasticizer compound is a rubbery material which is useful, in addition, as a high energy binder for various other ingredients, Dr. Camp said.

He revealed further that his group has passed somewhat beyond the material. "We have another way of using nitrocellulose in a binder which is even more attractive and considerably simpler chemically" than the cross-linked system, he disclosed.

New Rocket Motor Fires For More than 8 Min

A new type of rocket motor, intended for small, very high speed flight systems, uses a solid fuel to sustain a firing duration in excess of 8 min. Developed by the Rocket Fuels Div. of Phillips Petroleum Co., the same principles used in the rocket can be applied to many other rocket propulsion and gas generating systems. Propellants employed are made from readily available synthetic rubber, fertilizer grade ammonium nitrate, carbon black and other low-cost petroleum products.

Astronautical Engineers

(CONTINUED FROM PAGE 53)

which can offer a degree in any other phase of engineering but astronautics. This may prove adequate for a career, but hardly fulfills the student's original desire to study the engineering principles of space flight.

It is long past the time when the establishment of a degree in astronautical engineering must be given serious consideration by higher institutions of learning. Most of the difficulties in any such effort will center around the choice of a proper curriculum. Much the same problems were faced earlier in preparing an appropriate course of study for an aeronautical engineering degree. In 1955, however, there were already 32 recognized colleges and universities offering a degree in aeronautical engineering. A survey of 26 of these schools shows the curricula were very nearly the same. This is certainly an indication that educators are capable of determining, from all available statistics and from new industrial demands, a uniformly correct engineering curriculum.

Why, then, is this not possible in the field of astronautics? An astronautical engineer is still an engineer. An excerpt from the Engineers' Council for Professional Development booklet entitled, "Differentiating Characteristics of an Engineering Curriculum," may help clarify this point:

> "An engineer is characterized by his ability to apply creatively scientific principles to design or develop structures, machines, apparatus, or manufacturing processes, or works utilizing them singly or in combination; or to construct or operate the same with full cognizance of their design, and of the limitations imposed by such design; or to forecast their behavior under specific operating conditions; all as respects an intended function, economics of operation, and safety to life and property."

Applies Without Modification

This definition can be applied to the astronautical engineer without modification. The "structures" or "machines" are, of course, missiles or space vehicles, which will operate "under specific operating conditions" and the behavior of which must be "forecast."

Considering the close similarity between the aeronautical and astronautical engineer, why not establish an astronautics curriculum similar to that of its respected predecessors?

A course of this type could parallel the typical aeronautical engineering curriculum and might even be identical with it in the freshman year. Thereafter, the two curricula would diverge, with only those courses basic to both fields of study retained in the astronautical curriculum.

Thus the astronautical engineering curriculum might substitute courses in missile systems, rocket engines, space vehicle structures and design, hypervelocity flight, thermodynamics, etc., for courses specifically related to the field of aeronautical engineering.

The establishment of a curriculum of this type is no easy matter, determining what should or should not be included would involve some serious thought and many important decisions. However, it is something which should be discussed now, so that we may in the near future see the establishment of an astronautical engineering faculty at one of our leading engineering institutions.

Odd though it may seem, the young student seeking advice concerning a course of approach to astronautical engineering, in the absence of a specific curriculum of this type, is likely to be disappointed. An intensive search through a field rich in technical literature reveals only two carefully thought out, significant articles on the subject. The first of these, which appeared in JET PROPULSION in September 1956, was written by George P. Sutton, who commented:

> "In his choice of curriculum, the student should emphasize science and basic engineering, together with broad general studies, as opposed to practical and descriptive courses in engineering.
>
> "Fundamental understanding is the basis for a wide field of endeavor and is equally applicable for any specific engineering career. Practical 'know-how' changes with the times and rapidly becomes obsolete as new discoveries are made.
>
> "The student should not choose his detailed specialty until he has been working for some time as an engineer or scientist in the field. At that time he will have gained an insight into the structure of the organization and the engineering problems presented; he will have a better understanding of the opportunities offered in various specialties; and he will have achieved a better self-appraisal of his own personality traits and limitations.
>
> "The choice of a major, such as chemical engineering or physics, should not be influenced by eventual employment in the rocket industry but be guided by the interests, preferences and personal characteristics of the student."

Another excellent treatment of this subject was found in an article by Charles S. Draper (Proceedings of the American Astronautical Society, 3rd Annual Meeting, Dec. 6–7, 1956, New York.) After outlining the need for a curriculum in astronautical engineering, he continues:

> "After the science and humanities aspects of his education are built up, the astronautical engineering student should look toward another group of courses to complete his qualifications for starting a professional career. These courses may be roughly divided into four fields: 1) Aerodynamics, which is necessary if take-off, atmospheric re-entry, and landing problems are to be understood; 2) structures, which is of fundamental importance if vehicles able to withstand the loads of operation are to have the smallest possible weight; 3) propulsion, which is the key to feasibility for all flight vehicles, particularly those which are designed to operate beyond the earth's atmosphere, and must include the study of chemical-powered rockets, nuclear-powered rockets, and more exotic propulsion means that are still largely in the stage of fantasy; and 4) control, which must be applied to all the essential functions of vehicle operation and navigation, including power plant operation, gyroscopic stabilization, air conditioning, computation and storage of data, flight path and so forth."

Analyzes the Problem

Dr. Draper does not attempt to describe the fine details of an astronautical engineering curriculum. However, he presents a cursory analysis of the problem, and concludes:

> "There is little hope that any one individual will be able to completely handle all phases of the job, but it is very desirable for the astronautical engineer to understand all the basic questions involved well enough for him to intelligently coordinate the efforts of the mechanical, electrical, electronic, propulsion, structural, and other engineering specialists who must work together in bringing any astronautical system to the stage of successful operation."

It is interesting to note that, if immediate action were taken by even a few of our colleges, the first group of astronautical engineers would be graduated within five years.

Woomera Range Extended

The long-range weapons establishment and missile range at Woomera has been extended in width to embrace many thousands of square miles of South Australia. The announced expansion indicates a British IRBM may be tested at the range.

Underwater Propulsion Moves Ahead

(CONTINUED FROM PAGE 37)

body of revolution, arranged coaxially with it so that the intake receives the boundary layer whose momentum deficiency over the free stream accounts for a large part of the drag of the body. Using this type of pump jet, a propulsion advantage over the internal type can therefore be realized. Other advantages over the propeller include less cavitation and noise.

Test Facilities Described

To perform development work in water propulsion, three types of facilities are used: The towing tank, the water tunnel and the rotating arm. The towing tanks, or model basins, are used chiefly for free-surface studies of the general problems of naval architecture. The water tunnels are used for continuous-operating studies of resistance, cavitation and propulsion, and general hydrodynamic studies. However, because of the high density of water, high speeds in large tunnels usually require prohibitive powers. Therefore, for very high speeds, rotating arms are useful. The rotating-arm facility at Aerojet, which was built in cooperation with the Office of Naval Research, was the first system capable of speeds up to 100 knots and large-scale tests. Recently, the British Admiralty built a similar facility at Teddington, England.

The Aerojet ring channel is shown on page 36. The outer diameter is 110 ft, and the rotating arm has two test radii of 40 and 50 ft. The channel is 12 ft deep and is equipped with underwater windows for high speed microflash photography. The boom is completely equipped for handling propellants, and is instrumented remotely so that a wide variety of work can be accomplished over and above straight, hydrodynamic measurements.

Some years ago, we began towing underwater swimmers equipped with SCUBA (self-contained, underwater breathing apparatus) on the rotating arm. The resistance measurements obtained thereby have served, since then, as a basis for the development of swimmer propulsion devices. One of the devices, the "AquaPed," was based on the application of aircraft-type propellers to swimmer propulsion. We took the design charts for subsonic aircraft propellers, and, with the known resistance of the swimmer and allowing for the density ratio between water and air, we selected the pitch and diameter for contra-rotating, two-bladed propellers which would then operate at a peak efficiency of over 80 per cent. The rotative speed turned out to be surprisingly low, about 120 rpm at 2.0 knots, and was suitable for foot-pedal drive with a step-up gear ratio.

Various Fairings Tried

The drag tests on the human body, particularly with the SCUBA, focused attention on its high underwater resistance. Consequently, various fairings were tried, still using the slow-turning, efficient aircraft propellers.

Finally, after many model changes, the MK VI and MK VII "MiniSubs," shown on page 37, were developed as freely flooded submersibles, with either foot or electric power.

The MK VI is so highly streamlined that, although its submerged displacement is about 3700 lb, its drag is only one-third that of the human body. The resistance is just slightly above the smooth-plate skin resistance, based on the wetted area. The power requirement at 6 knots is only 0.5 shaft hp, and one man can pedal the craft at a little over 3 knots almost indefinitely.

This is the first submersible to perform all the maneuvers that an airplane is capable of, such as rolls, loops and Immelmanns. The four swept-down fins provide triaxial control by the application of simultaneous or differential deflections in all combinations. These are applied by means of a single control stick.

Employed in Same Manner

It is interesting to note that many of the efficient swimmers in nature, such as the porpoise and the shark, have swept-down fins arranged in a similar manner, and that they are employed in the same manner.

This craft is always run buoyant and is "flown" under water. Its minimum speed for submergence is about 1 knot. In principle, it is the inverse of the airplane, and power failure causes it to surface, a safety feature.

A good deal has already been accomplished in the underwater propulsion field, but much still remains to be done. The stir caused by Mr. Kimball's recent remarks may awaken new interest in what, to some of us, is one of the most interesting applications of the jet propulsion principle.

New Discovery Multiplies Radar Range

Columbia University last month announced a new discovery in the field of radar which is expected to simplify development of defenses against long-range missiles and improve communications over long distances and out in space.

Hailed as the greatest single advance in radar since 1939, the new technique was developed over the past three years at the university under an Air Force R&D contract. It makes possible tracking of long-range missiles over distances well beyond the range of present radar units.

Maximum effective range of current radar is several hundred miles. Extending this range significantly would involve tremendous increases in the power supply. For example, doubling the range would necessitate about a 16-fold increase in power or the weak signals returned from missiles would be lost among atmospheric noise.

The Columbia team has discovered a sophisticated method of multiplying the effective range of radar without increasing the power supply. Exact extent of the increase has not been announced for security reasons.

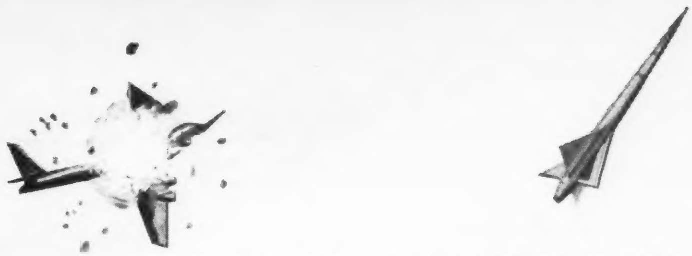
In the Columbia technique, a method has been found of making weak signals of this type distinguishable. The radar transmitter sends out a frequency-modulated signal, essentially continuously when compared to pulse radar transmissions, that has been "tagged." This coded characteristic is recognized on its return from the target.

The total amount of energy emitted in a single pulse of conventional radar is equal to the amount sent out by the Columbia radar during the time the pulse is transmitted and its echo awaited, for the same target range.

The first successful test was carried out in March at the university's Edwin H. Armstrong Laboratory at Alpine, N. J. The Air Force is said to be "highly satisfied" with the device, but a good deal of testing lies ahead before it can be translated into operational units.

The new radar, like current units, works on a line-of-sight basis. It is expected to be adapted as a specialized addition to current installations, rather than as a substitute for units now in use.

Columbia scientists noted that the technique could be used for tracking earth satellites and, eventually, manned space vehicles. However, no speed-up is planned to turn out finished equipment which could be used to track the Vanguard satellites.



This is

NATIONAL NORTHERN

...newest AP&CC division

Dedicated to research, development and production in

rocket power technology

Test a rocket motor's performance at 100,000 feet altitude...determine how extremes of temperature affect explosive and propellant charges...develop igniters of maximum sturdiness and reliability. These are typical activities at National Northern Division, West Hanover, Mass., latest addition to the AMERICAN POTASH family. Here, a qualified staff of scientists and technicians conducts research, development, field testing and production of propellants for rockets and missiles, explosives, pyrotechnics, detonators, igniters, squibs, gas generators, fuzes and other items.

Extreme environmental conditions are simulated in the laboratory or encountered in actual field tests on the firing range at West Hanover or the 1900-acre test range at Halifax, Mass. Here, too, AP&CC will extend its facilities for the investigation and development of TRONA* boron, lithium and perchlorate chemicals in high energy fuels.

For more than ten years National Northern has demonstrated its ability to work in close coordination with others. As an integral part of AMERICAN POTASH & CHEMICAL CORPORATION it is ready to go to work for you!

We invite inquiries leading to research and production contracts.

NATIONAL NORTHERN'S CURRENT FIELDS OF ACTIVITY:

ROCKET-MOTOR-IGNITER DEVELOPMENT • GAS GENERATORS • SURVEILLANCE TESTING OF EXPLOSIVES AND AMMUNITION • EFFECT OF ALTITUDE ON PERFORMANCE OF EXPLOSIVES, PROPELLANTS, TRACERS AND INCENDIARY ELEMENTS • DESIGN OF ELECTRIC DETONATORS AND SQUIBS • AIRCRAFT VULNERABILITY TESTS AND EVALUATION • EXPLOSIVE METAL FORMING

TRONA*

American Potash & Chemical Corporation

3030 WEST SIXTH STREET, LOS ANGELES 54, CALIFORNIA
99 PARK AVENUE, NEW YORK 16, NEW YORK
NATIONAL NORTHERN DIVISION

capital wire

News highlights from Washington

ARMED FORCES

• Joint Army-Air Force committee is quietly working on anti-missile missiles, not only to preclude fight over control when the missiles become operational, but also to avoid duplication of effort. Army still has unchallenged control over A-M missile use. Also under purview of the committee are defense coordination in time of missile attack and patterns of counterattack against enemy launching sites.

• Zeus, "about a fourth cousin of the Nike-Ajax," seems established as our first A-M missile. Army R&D Chief Gavin recently informed Congressmen A-M weapon would grow out of the Nike family.

• Army finally denied reports that it had developed to the point of testing a 600–800 mile medium-range ballistic missile. Only "limited feasibility studies" of the type permitted in the controversial Wilson memorandum had been conducted, it said. Reports that ABMA had built six test vehicles were categorically denied: "No missiles of this so-called medium range have been constructed nor are any on order."

In any case, Defense Secretary Wilson seems to have effectively squashed the project, commenting pointedly: "If they're going ahead with it, I don't think they're going very far." He added crushingly, the project was "99.85 per cent out."

A liquid-fueled weapon, the MRBM was supposed to boast new instrumentation while using other elements developed in previous programs. A DOD official explained that a number of enthusiastic contractors had prematurely submitted bids to build the MRBM, speculating that the combination of these bids plus ABMA studies produced the flurry of MRBM reports.

• AF is considering allowing Air National Guard to help use some guided missiles, particularly the "area defense" Bomarc weapon. An ARDC study found the Guard capable of operating missiles because of its geographical dispersion and high level of skill.

• Keel was laid for the Mahan, one of 10 guided missile frigates authorized for the Navy. She will carry Terrier surface-to-air weapons. Displacement will be 5000 tons, speed should be over 30 knots and cost $20 million without electronics. Launchers will be aft, with 5-in. guns forward.

• The Army is activating its first Field Artillery missile group this month at Huntsville, Ala. The group will be armed with Redstone missiles.

• A group made up of 121 service technicians and civilians has been sent by the Army to man six Minitrack stations reaching down to Chile.

DISARMAMENT

• A first-step agreement to ban "outer space missiles" has been proposed to the five-power disarmament talks in London by the U. S. Three months after the agreement takes effect, a committee of international scientists would begin to study ways of insuring that such weapons would be used only for research. Presumably, air-breathing missiles would be excluded from the ban. Russia wanted time to study the suggestion. Like the ban on nuclear bombs, however, the missile ban is tied to an inspection system that has stalemated such talks for the past decade.

MISSILES

• "Authoritative" reports that put Russian missile progress behind ours have been attacked as being purposely leaked by the Administration to soothe the public when it becomes known that the missile slice of the defense budget has arbitrarily been limited to 10 per cent.

Professional DOD scientists, decrying such politically inspired estimates, believe both countries are moving at the same rate, give or take some special field. However, they feel the U. S. will be ahead at the end of the race because of our relative profusion of scientific mechanisms for evaluating data, and because of our proved capacity to translate research into production in a minimum of time.

• Firings of Atlas and other missiles are becoming so important to the consumer press that one national magazine is said to follow AF Missile Chief Schriever around the country. The theory is that, when he's at Cape Canaveral, a big one will probably go up. It worked for the first Atlas firing, incidentally.

• Secrecy at Patrick AFB seems ludicrous, with spectators always on hand days before a shot, watching the missile even on its launching pad. A recent early morning firing was so well attended that it caused a traffic jam at 4:30 a.m.

• Atomic Energy Commission revealed in its semiannual report that nuclear powerplants for rockets and ramjets were in an "early developmental stage" at Los Alamos and Livermore Laboratories. Presumably, fission, rather than fusion, is the nuclear process being used.

INVESTIGATIONS

• House subcommittee has charged DOD with forcing jet engine contract switch from General Electric to Curtiss-Wright, increasing cost to government from $3 million to $25 million. Purpose was to bail out ailing Studebaker-Packard by equipping one of its idle plants to do the contract work. The Air Force objected strongly to the move.

The Subcommittee also accused General Motors of "overstating" or "misstating" cost figures on $375-million jet fighter contract, resulting in $17½ million profit over that considered reasonable by the government. GM, replying that its total profit after taxes was only $20 million (5.4 per cent) at first refused to open its books to federal auditors, later changed its mind.

FINANCES

• Senate-House differences on defense budget were compromised, with $33.8 billion okayed,

versus $36.1 asked by DOD. A higher amount proposed by the Senate was cut after Defense Secretary Wilson announced manpower reductions and the Budget Bureau "secretly" predicted the executive branches would save $1 billion anyhow. Broken down, AF gets $15.9 billion new spending authority, Navy $9.9 billion, Army $7.3 billion and DOD housekeeping the rest.

• President Eisenhower's promised delivery of IRBM's to England may be jeopardized by zooming missile costs. About $240 million is now needed to supply Britain as originally planned, but only $90 million was reportedly set aside in defense funds.

• Further defense procurement cuts or contract stretch-outs may be made in some missiles, Defense Secretary Wilson hinted. Over-all spending for the year will be cut between 6 and 8 per cent, he predicted, but some areas may feel slashes as deep as 20 per cent to avoid taking funds from high priority programs like ICBM's.

• Missile procurement and production ate up $2 billion of the $38.2 billion spent by DOD during fiscal 1957 ending June 30. Aircraft cost $8 billion, research and development another $1.7 billion.

EARLY WARNING SYSTEM

• Operation of the $600-million "Dew Line" radar string along the Arctic Circle began on schedule. Three to six hours of warning are promised for U. S. cities on enemy aircraft approaching over the Pole between Alaska and Baffin Island. Western Electric started building the system almost three years ago.

RANGE AIR SPACE

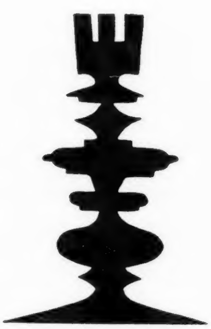
• Civil Aeronautics Board has revoked right of military services to declare air space off limits to commercial airliners. Air over missile test ranges should not be affected by the decision.

SATELLITE

• Navy will undoubtedly get the extra $34 million it asked to finish the earth satellite program. Rising costs plus correction of three technical problems consumed that much early this year. Total Vanguard cost is now placed at $110 million "barring a major calamity."

The problems, "which cost money to fix," said Adm. Bennett, research chief, were local hot spots in the first-stage engine, corrected by better quality control of the nozzles and injectors; a "somewhat similar" defect in the second-stage engine; and "computational suspicion that vibration, etc., would set up within the vehicle frame," requiring re-engineering of the structure.

SDD needs an aeronautical engineer who might aptly be described as a specialist in the element of choice.
He will be required to evaluate equipment and equipment systems for purposes of incorporation into a major nation-wide system.
The position requires general familiarity with a wide range of technical subjects, including missiles, interceptor aircraft, and electronic systems, with recent specialization in at least one of these.
The ability to think in broad concepts, while retaining mastery of subordinate but complex factors, is also necessary.



THE ELEMENT OF CHOICE

This engineer must be qualified to keep up with advancements in his field, through liaison with other departments and companies.
Call collect or write for more information.

System Development Division
The Rand Corporation
2400 Colorado Ave., Santa Monica, Calif. GRanite 8-8293, Extension 53 or 54

11-8

Commercial Rockets

(CONTINUED FROM PAGE 23)

hour, travel over and through any kind of weather, and be economical enough in capital cost, maintenance and operation to permit standard scheduled airline operation.

5. *Space flight.* This one is further away—but probably not so very far beyond the first successful ICBM's, at that. Little imagination is needed to perceive that space flight could grow into quite a commercial business, based on space research, thirst for adventure, tourist curiosity, possible colonizing of the moon and planets, mining ventures, commercial transport of rare, unsual new products and curios, etc.

6. *Chemical production.* A good deal of experimental work has been carried out in this field, using jet engine and rocket motor types of combusion to produce unusual chemical reactions at high speeds, continuously and at high temperatures. It may offer many commercial possibilities.

7. *Drilling, boring, cutting.* Using high velocity jets, with or without the simultaneous use of reactive gases, to dig blast holes in refractory rocks such as taconite; to shape, cut or drill refractory materials, etc.

8. *Photographing, mapping, exploring and searching from medium altitudes.* Numerous military and research photographs and motion pictures taken from high altitude rockets show the possibilities. Needed is a photographic rocket that is light, easy to transport over all types of terrain, simple to launch, safe, reliable and relatively inexpensive to use, with landing apparatus making possible the safe return of photographic equipment and permitting reuse of the rocket.

9. *Deep sea soundings, research and seismographic work.* Underwater rockets capable of reaching great depths, driving or carrying research apparatus, photographic equipment and lights, equipment for bringing up samples of mud, ooze and undersea rock, or setting off seismographic charges at the bottom of the ocean deeps.

10. *Spectacles, entertainment, fireworks displays.* One of the oldest uses of rockets could now take on new dimensions, with the velocities, altitudes, guidance, control and load-carrying capability now available. Spectacles put on by Italian fireworks makers of the 17th century charmed the courts of kings. Displays based on today's rocket technology could astonish, entertain, warn, alert or inform whole nations or hemispheres at a time. As advertising media, such displays might even outdo television in attractiveness, impact and communicative power.

In almost every area of human interest or desire there may be uses for rockets, jets or applications of the jet propulsion principle. Let us devote some portion of the rocket and missile industry's giant resources of brainpower, experience, imagination and productive capacity to seeking out these possible uses, and establishing at least the beginnings of commercial industry *now*.

Lark Engine

(CONTINUED FROM PAGE 45)

in a cooperative program involving the BuAer Rocket Project at Annapolis, Md., Eclipse-Pioneer Div. of Bendix and Reaction Motors. About 80 of the engines were built.

Compared to the involved V-2 type system, which used the decomposition of hydrogen peroxide to spin the turbopump, the LR6 was simple and yet retained many of the weight and volume advantages associated with pumping systems. Compared to the LR2-RM-2, an interim Lark engine used pending completion of the LR6, it nearly doubled the missile's range.

Used Two Thrust Cylinders

The LR6, like the LR2, used two regeneratively cooled thrust cylinders, one developing 220 lb of thrust and the other 400 lb. Both cylinders were developed from the 350-lb-thrust unit of the old Gorgon test missile.

The exhaust from the smaller cylinder was used to drive the turbine. The cylinder itself was scaled down, although its nozzle was given a greater expansion ratio because it was designed to operate primarily at altitude. The 400-lb cylinder was identical in size with the Gorgon unit, although chamber pressure was hiked from 275 to 315 psi to increase thrust.

Considerably better performance was achieved in both the LR6 and LR2 engines by making improvements in the Gorgon injector. Further, improved fabrication techniques provided better cooling in the regenerative jacket. Nitric acid oxidizer was used as the coolant.

The primary difference between the LR2 and LR6 lies in the feed mechanism. The LR2 depended on propellant tanks capable of withstanding 500 psi and on a sizable compressed gas propulsion system; the LR6, on two pumps commonly driven by a turbine and requiring a supply pressure of less than 50 psi.

A complete description of the LR6 and its development is available in ARS Preprint 440–57.

More Ceramic Materials For Use in Missile Radomes

Ceramic and ceramic-like materials appear to be the dominant substances being developed for missile radomes. Gladding, McBean & Co. of Los Angeles has completed a research and development project resulting in production of experimental ceramic radomes, while Mycalex Corp. of America has announced a ceramoplastic based on mica which it is promoting for missile radar noses.

In addition, Corning Glass Works recently announced Pyrocerams, a family of crystalline materials made from glass and particularly suitable for radomes (see JET PROPULSION, June, p. 690).

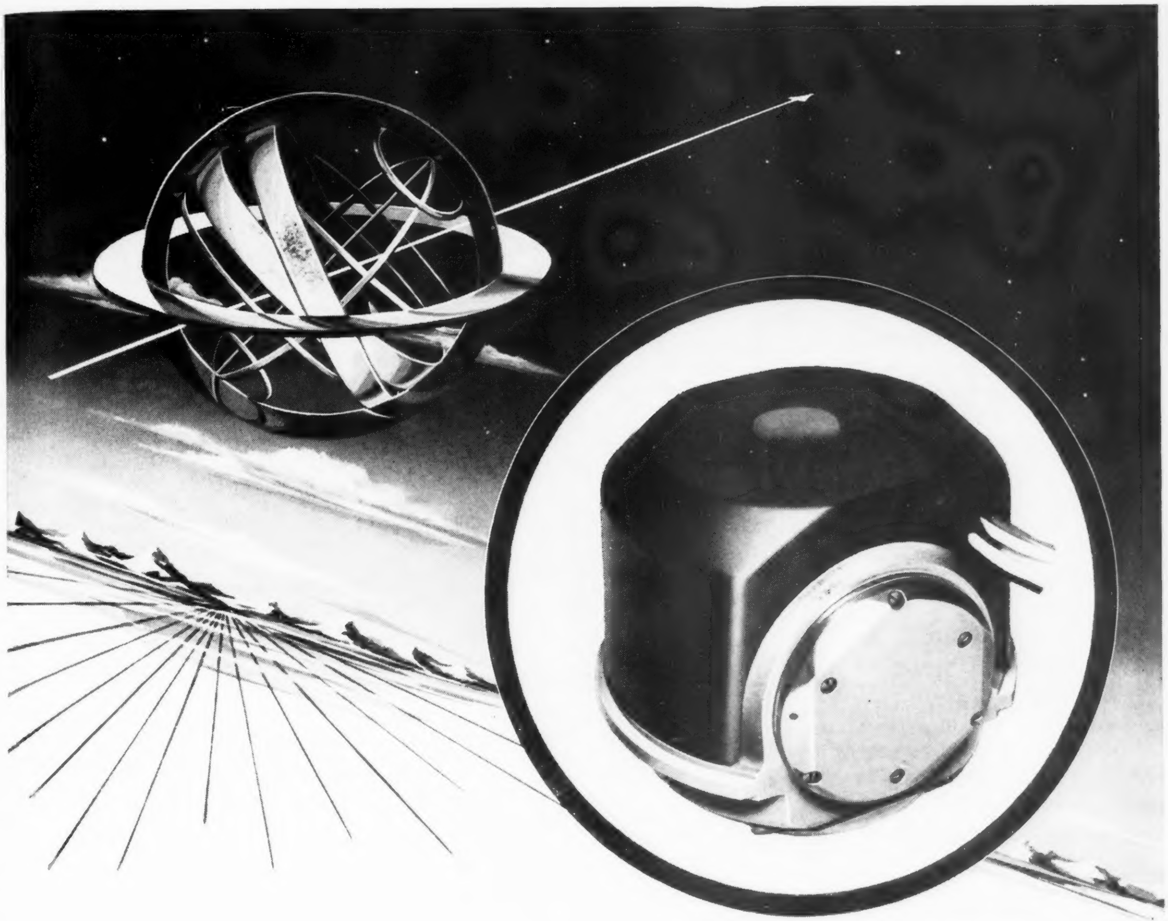
The pure ceramic product is claimed by Gladding, McBean to be transparent to radar waves, unaffected by extremely high temperatures and the corrosive actions of hypersonic flight, and as hard as a diamond.

Mycalex' ceramoplastic is called Supramica 555. It is described as a molding material that uses synthetic mica and is capable of being machined to close tolerances. The company suggested it for radomes after preliminary investigations, it said.

Properties of Supramica 555 that recommend it for radome applications include excellent electrical characteristics said to be superior to those of glass-bonded mica; total and permanent dimensional stability; thermal expansion values matching those of steel; and ability to withstand temperatures up to 950 F. Mounting rings and reinforcing metal can be molded into the product to give better stress resistance. Ceramoplastics are also claimed to be tougher than ceramics or glass because of synthetic mica "platelets" in the material that stop cracks.

Missile Master to Control Firing of Hawk Missile

The Missile Master System, an electronic system for controlling and coordinating fire of Nike antiaircraft batteries, has been extended to the Hawk, a recently developed low altitude air defense missile. The Missile Master locates and identifies aircraft and conveys the information to battery commanders.



Model II B Accelerometer

INERTIAL GUIDANCE . . .

a Breakthrough by Bell Aircraft

The high precision, II B linear accelerometer, now in quantity production, is one of many examples of the recent dramatic progress of the *Avionics Division* of Bell Aircraft Corporation in the field of inertial instrumentation. With a range of ± 25 g's and a frequency response of 0 to 350 cps, its performance is rated by leading authorities as exceeding all others now available.

As one comparatively small detail in Bell's overall inertial guidance program, the accelerometer is indicative of much broader more advanced accomplishments by Bell's team of instrumentation experts. This and their other successful developments . . . the knowledge they have gained in over 20 years of work on inertial components . . . are available to other missile and guidance system builders in advancing the frontiers of technological achievement. For information write: Sales Manager, *Avionics Division*, **BELL AIRCRAFT CORP., Post Office Box One, Buffalo 5, N.Y.**

BELL *Aircraft* CORP.

Avionics Division

BUFFALO, N. Y.

government contract awards

McDonnell Gets $4 Million Quail Development Contract

Development of a new Air Force missile, the Quail, is under way at the McDonnell Aircraft Co. of St. Louis, recipient of a $4,539,772 contract from the Air Materiel Command.

Signal Corps Orders Military-Type Atomichrons

The U. S. Army Signal Supply Agency has awarded a $609,525 contract to National Co., Inc., of Malden, Mass., for the development of military-type Atomichrons. National's engineers are adapting it for use in electronic warfare systems. The instrument is allegedly the first to utilize the atomic principle of frequency control.

Martin Co. Lets Contract For Oscillograph Systems

Consolidated Electrodynamics Corp. has received a $146,900 contract from The Martin Co. for six recording oscillograph systems which the latter will use during guided missile instrumentation system check-out and missile ground and flight tests.

AF Contract for Sperry

The Air Force last month announced a $1,298,518 contract award to Sperry Gyroscope Co. for the production of a flight data system for all flying attitudes—climb, descent, level flight, and turns and maneuvers—for a secret high performance aircraft "operating under missile-like conditions."

SYNOPSIS OF AWARDS

The following synopsis of government contract awards lists formerly advertised and negotiated unclassified contracts in excess of $25,000 for each Air Force, Army and Navy contracting office:

AIR FORCE

AF Cambridge Research Center, ARDC, USAF, Laurence G. Hanscom Field, Bedford, Mass.

Study of infrared solar radiation, $29,640, **University of Denver**, University Park, Denver 10, Colo.

Research directed toward conducting studies of ionization created in the ionosphere by ejection of chemicals from rockets, $68,000, **Leland Stanford Jr. University**, Stanford, Calif.

Design study of a booster control system for the Aerobee rocket, $66,916, **Aerojet-General Corp.**, 6352 N. Irwindale Ave., Azusa, Calif.

AF Missile Test Center, ARDC, Patrick AFB, Fla.

Liquid oxygen semitrailers, storage and servicing, $100,814, **Cambridge Corp.**, Industrial Park, Lowell, Mass.

Aviation Supply Office, 700 Ribbins Ave., Philadelphia 11, Pa.

Jet engine installations and removal trailers, $627,695, **Air Logistics Corp.**, 3600 E. Foothill Blvd., Pasadena, Calif.

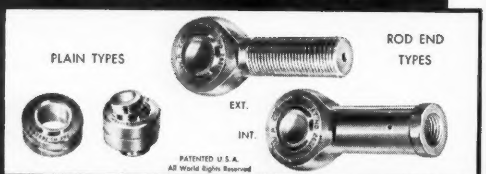
Base Procurement Office, USAF, Eglin AFB, Fla.

Decommutator, PAM/PWM telemetering, $39,601, **Ralph M. Parsons Co., Electronic Div.**, 135 W. Dayton St., Pasadena, Calif.

Commander, HQ AMC, Wright-Patterson AFB, Ohio.

Radio-receiver and radio modulator for

"MONOBALL"®
Self-Aligning Bearings



CHARACTERISTICS

	ANALYSIS	RECOMMENDED USE
1	Stainless Steel Ball and Race	For types operating under high temperature (800-1200 degrees F.).
2	Chrome Alloy Steel Ball and Race	For types operating under high radial ultimate loads (3000-893,000 lbs.).
3	Bronze Race and Chrome Steel Ball	For types operating under normal loads with minimum friction requirements

Thousands in use. Backed by years of service life. Wide variety of Plain Types in bore sizes 3/16" to 6" Dia. Rod end types in similar size range with externally or internally threaded shanks. Our Engineers welcome an opportunity of studying individual requirements and prescribing a type or types which will serve under your demanding conditions. Southwest can design special types to fit individual specifications. As a result of thorough study of different operating conditions, various steel alloys have been used to meet specific needs. Write for revised Engineering Manual describing complete line. Dept. AST-57.

SOUTHWEST PRODUCTS CO.
1705 SO. MOUNTAIN AVE., MONROVIA, CALIFORNIA

ARS LUNCHEON

September 24

(Held under the auspices of the Connecticut Valley Section in conjunction with The ASME Fall Meeting)

Featured speaker will be

COL. JOHN P. STAPP

who will discuss space

medicine experiments

at the

HOTEL STATLER

Hartford, Conn.

Atlas, Thor and Titan missiles, $146,050, **Avco Mfg. Corp., Crosley Div.**, 1329 Arlington St., Cincinnati 25, Ohio.

Director of Procurement, Brookley AFB, Ala.

Card assembly applicable G1/G2 thrust selector, $275,531, **General Electric Co., Aircraft Gas Turbine Div.**, Cincinnati 15, Ohio.

HQ, Wright Air Development Center, ARDC, USAF, Wright-Patterson AFB, Ohio.

Twenty items of high temperature glass, $78,179, **Corning Glass Works**, Corning, N. Y.

San Antonio R&D Procurement Office, ARDC, P.O. Box 63, Lackland AFB, San Antonio, Texas.

Additional funds for research and reports on effects of ionizing radiation upon physiological and psychological functions of various species, $32,000, **University of Texas**, Austin, Tex.

Research on automation and personnel requirements for guided missile ground support functions, $123,405, **General Electric Co.**, French Rd., Utica, N. Y.

ARMY

Army Chemical Center, Procurement Agency, Army Chemical Center, Md.

Experimental fabrication of instrumented bomblets of various types for engineering tests of guided missiles and rocket warheads, $37,775, **Bendix Corp.**, 1400 Taylor Ave., Baltimore 4, Md.

Chicago Procurement Office, U. S. Army Corps of Engineers, 226 W. Jackson Blvd., Chicago 6, Ill.

Component parts for 20-ton lox generating and charging plant, $435,007, **Air Products Inc.**, PO Box 538, Allentown, Pa.

Cincinnati Ordnance District, 230 E. Ninth St., Cincinnati 2, Ohio.

Investigation of the theoretical performance of high energy propellants, $68,099, **General Electric Co.**, Cincinnati 15, Ohio.

Cleveland Ordnance District, 1367 E. Sixth St., Cleveland 14, Ohio.

Operations of the Berkley spiral tube mill to produce JATO M5, $118,100, **Goodyear Aircraft Corp.**, 121 Massillon Rd., Akron, Ohio.

Corps of Engineers, Louisville District, PO Box 59, Louisville, Ky.

A-C test and missile equipment, Wright-Patterson AFB, Ohio, $1,049,250, **Hughes-Simonson, Inc.**, 20 N. McGee St., Dayton, Ohio.

Military Petroleum Supply Agency, Washington 25, D. C.

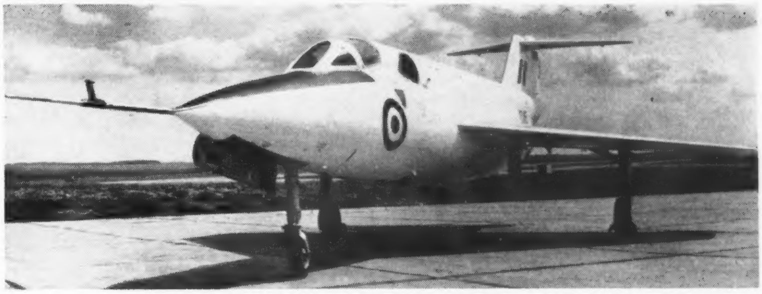
Rocket fuel, 1,358,000 gal, **Bell Oil & Gas Co.**, 1310 National Bank of Tulsa Bldg., Tulsa, Okla.

Rocket fuel, 6,815,000 gal, **Standard Oil Co. of Calif., Western Operations, Inc.**, San Francisco, Calif.

New York Ordnance District, 180 Varick St., New York 14, N. Y.

Engineering and design services for the selection and installation of air-handling equipment for a hypersonic wind tunnel, $41,459, **Burns and Roe, Inc.**, 160 W. Broadway, New York 13, N. Y.

British Rocket Research Aircraft



The Saunders-Roe S-R.53 interceptor research aircraft, a single-seater powered by a de Havilland Spectre rocket engine and an Armstrong Siddeley Viper jet engine, is the first manned British aircraft with a rocket as its main powerplant.

Engineering and scientific studies required in advanced guided missile projects, $43,542, **General Astronautics Corp.**, c/o Laurence Rossbach, 11 W. 42 St., New York 36, N. Y.

Anhydrous hydrazine, $148,526 and $153,648, **Olin Mathieson Chemical Corp.**, 460 Park Ave., New York 22, N. Y.

Philadelphia Ordnance District, 128 N. Broad St., Philadelphia, Pa.

Study of motion of spin-stabilized rockets, $55,125, **University of North Carolina**, Raleigh, N. C.

Nike spare parts and components, $2,467,734 **Western Electric Co. Inc.**, Burlington, N. C.

Research on the vulnerability of aircraft and missiles, $140,000, **The Johns Hopkins University**, Baltimore 18, Md.

Test for aerodynamic heating, $156,568, **Research Institute of Temple University**, Philadelphia, Pa.

Picatinny Arsenal, Dover, N. J.

Warhead stand assembly, $43,988, **Nuclear Energy Products, ACF Industries Inc.**, 30 Church St., New York 80, N. Y.

Section D of Corporal Missile, $25,527, **Firestone Tire & Rubber Co.**, 2525 Firestone Blvd., Los Angeles 54, Calif.

Redstone Arsenal, Huntsville, Ala.

Hydrogen peroxide 90%, 76% c.p. grade, and deposit on aluminum drums, $46,134, **E. I. du Pont de Nemours & Co.**, Wilmington, Del.

Liquid oxygen in tank cars, $49,500, **Linde Co.**, 2900 Cahaba Rd., Birmingham, Ala.

Shipping container, AFT section, missile body XM351, $359,633, **Fruehauf Trailer Co.**, 10940 Harper Ave., Detroit, Mich.

Engineering design study, development fabrication and installation of equipment for expansion of existing missile testing facilities, $889,609, **Aerojet-General Corp.**, Azusa, Calif.

Continued design, development, testing fabrication and delivery of modified XM20 rocket engine, $486,341, **Thiokol Chemical Corp.**, Trenton, N. J.

Manufacture loading and delivery of XM10 LaCrosse rocket engine, $27,711, **Thiokol Chemical Corp.**, Trenton, N. J.

Continued research and development of solid propellant rocketry, $30,500, **Rohm & Haas Co.**, Philadelphia, Pa.

Continued development of full scale solid propellant sustained engine B, $312,979, **Thiokol Chemical Corp.**, Trenton, N. J.

Continued development of XM17 rocket engine, $36,596, **Thiokol Chemical Corp.**, Trenton, N. J.

Continued development of XM10 LaCrosse rocket engine, $26,861, **Thiokol Chemical Corp.**, Trenton, N. J.

Development and delivery of ducted rockets for flight tests, $28,281, **Thiokol Chemical Corp.**, Trenton, N. J.

Continued development of M58M4 rocket engine, $39,583, **Thiokol Chemical Corp.**, Trenton, N. J.

Development of C-73 boosters, $31,264, **Thiokol Chemical Corp.**, Trenton, N. J.

Research evaluation of fabrication methods of casting fixtures for solid propellant rocket engines, $38,447, **Thiokol Chemical Corp.**, Trenton, N. J.

San Francisco Ordnance District, 1515 Clay St., PO Box 1829, Oakland 12, Calif.

Study of certain aspects of radiating antenna systems—end use, guided missiles, $49,904, **Stanford Research Institute**, Menlo Park, Calif.

Services and supplies for pilot models of the Little John vehicle chassis—end use, Little John missile system, $1,207,373, **Food Machinery & Chemical Corp.**, San Jose, Calif.

U. S. Army Corps of Engineers, Office of the District Engineer, Jacksonville District, 575 Riverside Ave., Jacksonville, Fla.

Construction of guidance facility and administration and laboratory building, ABMA; guided missile control station (interference control facility); and alterations to missile assembly building, AFMTC, Patrick AFB, Fla., $470,623, **J. C. Harper Construction Co.**, 960 Orange Ave., Winter Park, Fla.

Construction of rocket storage building, FANG, Imeson Airport, Jacksonville, Fla., $49,611, **Wesley of Florida, Inc.**, 222 W. Beaver St., Jacksonville, Fla.

Construction of rail transfer system and reinforced concrete protective walls for helium lines, complex 17, AFMTC, Patrick AFB, Fla., $319,638, **Duval Engi-**

neering and Contracting Co., 1746 E. Adams St., Jacksonville, Fla.

U. S. Army Corps of Engineers, Office of the District Engineer, Los Angeles District, 751 S. Figueroa St., Los Angeles 17, Calif.

Special test track facilities at Edwards AFB, Calif., $3,012,290, **George A. Fuller Co.**, 3100 W. Eighth St., Los Angeles 5, Calif.

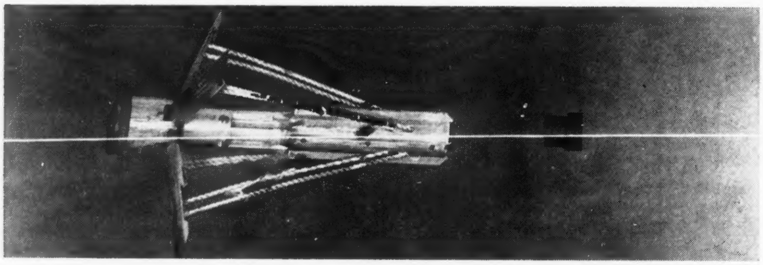
Rocket storage facilities at Ontario Municipal Airport, Ontario, Calif., $69,750, **Robinson & Wilson,** 179 W. Fourth St., San Bernardino, Calif.

U. S. Army Corps of Engineers, Office of the District Engineer San Francisco District, 180 New Montgomery St., San Francisco, Calif.

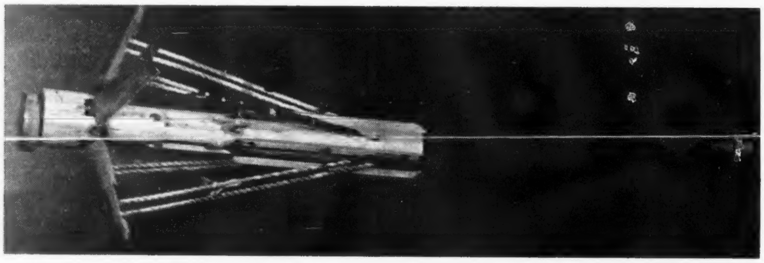
Rocket storage building, California Air National Guard Base, Fresno, $76,914, **Staiger Construction Co.,** 523 P St., Fresno, Calif.

GE's 'Nickel-Model' Nose Cones

At Mach 2, GE's new, nose cone separation unit . . .



. . . looks like a frightened squid.



General Electric's Missile and Ordnance Systems Dept., nose cone contractor for Atlas and Thor, has developed an inexpensive booster unit for making free flight tests of missile nose cone models.

Used in small-scale range firings to date, the unit, according to General Electric, is adaptable for the larger-scale free-flight tests that the company is planning in cooperation with NACA's Pilotless Aircraft Research Div.

The small-scale booster consists principally of an aluminum cylinder 28 in. long and 5 in. in diam. On and partially in the forward end of the booster sits a $3^1/_2$ in. nose cone model. The complete unit is fired from a 5-in. gun.

Once the unit is in the air stream, springs force open the four flaps, and nylon cords stop the flaps at 90 deg to develop maximum drag. The nose cone model then separates and continues its free flight.

Purpose of the operation is to enable aerodynamicists to study temperature, pressure and noise effects on afterbody structures. In the scaled-up version of the unit, instruments will measure these effects and telemeter data to ground receiving stations for analysis.

U. S. Army Corps of Engineers, Office of the Division Engineer, 150 Causeway St., Boston 15, Mass.

Construction of rocket storage building, Grenier AFB, Manchester, N. H., $87,361, **Roycraft Construction Co., Inc.,** 55 Nelson St., Manchester, N. H.

U. S. Army Corps of Engineers, Omaha District, 1709 Jackson St., Omaha 2, Nebr.

Construction of rocket storage facilities, Des Moines Municipal Airport, Des Moines, Iowa, $65,650, **Fargerstrom Construction Co.,** 3103 John Patterson Rd., Des Moines, Iowa.

Construction of rocket storage facilities, Cheyenne Municipal Airport, Cheyenne, Wyo. $78,236, **Garton & Garton Construction Engineers,** 1000 E. 15 St., Cheyenne, Wyo.

U. S. Army Engineer District, Chicago Corps of Engineers, 475 Merchandise Mart, Chicago 54, Ill.

Rocket storage building, Capital Airport, Springfield, Ill., $119,810, **Evans Construction Co.,** 1900 E. Washington St., Springfield, Ill.

U. S. Army Engineer District, Pittsburgh, Corps of Engineers, 925 New Federal Building, Pittsburgh 19, Pa.

Construction of jet engine test cell facilities at Youngstown Municipal Airport, Trumbull County, Vienna, Ohio, $183,477, Burnett Estes, doing business as **Shaw & Estes, contractors,** 1407 So. Akard St., Dallas, Tex.

U. S. Army Engineer District, Seattle, Corps of Engineers, 4735 E. Marginal Way, Seattle 4, Wash.

Jet test cell, McChord AFB, Wash., $179,500 **Technical Constructors,** PO Box 2488, Dallas 21, Tex.

Jet test cell, Geiger AFB, Spokane, Wash., $173,655, **P&B Co. Inc.,** E. 8903 Main St., Spokane 62, Wash.

U. S. Army Ordnance District, Los Angeles, 55 S. Grand Ave., Pasadena, Calif.

Design study for periscopic range finder, $107,316 **Northrop Aircraft, Inc.,** 1001 E. Broadway, Hawthorne, Calif.

Hypersonic research, $78,000, **California Institute of Technology,** 1201 E. California St., Pasadena, Calif.

Finned rocket system development, $39.671, **Hunter Douglas Aluminum,** 3016 Kansas Ave., Riverside, Calif.

Propellant tank, $62,842, **Southwest Welding & Mfg. Co.,** 3201 W. Mission Road, Alhambra, Calif.

Work re Zebra III, $276,454, **Rheem Mfg. Co.,** 9236 E. Hall Road, Downey, Calif.

Shipping containers for missile body XM351, $60,300, **American Pipe & Steel Corp.,** 2201 W. Commonwealth, Alhambra, Calif.

Environmental test unit, $150,000, **Paul Hardeman, Inc.,** 11558 Tennessee Ave., Los Angeles 64, Calif.

Engineering services related to Corporal missile system, $1,718,915, **Firestone Tire & Rubber Co.,** 2525 Firestone Blvd., Los Angeles 54, Calif.

Development, test and furnishing of prototype containers for Corporal mis-

sile warhead compartments, $30,140, **Lyon Aircraft Service Div., Lyon Van & Storage Co.,** 2701 N. Ontario St., Burbank, Calif.

Ground handling equipment for guided missiles, $41,160, **Firestone Tire & Rubber Co.,** 2525 Firestone Blvd., Los Angeles 54, Calif.

Warhead testers, $306,087, **Telecomputing Corp.,** 16217 Lindberg St., Van Nuys, Calif.

Warhead tester, $118,275, **Preshaw & Thompson, Inc.,** 14576 Oxnard, Van Nuys, Calif.

Replenishment repair parts, $75,000, **Gilfillan Bros. Inc.,** 1815 Venice Blvd., Los Angeles 6, Calif.

Material testing for plasma jet, $40,000, **Giannini Research Corp.,** 18400 S. Main St., Santa Ana, Calif.

Spare parts for the Nike system $147,095, **Douglas Aircraft Co. Inc.,** 3000 Ocean Park Blvd., Santa Monica, Calif.

Target drones, Model RP-77D, $1,587,-036, **Radioplane Co.,** 8000 Woodley Ave., Van Nuys, Calif.

Supplies and services for missile targets, $4,551,700, **Radioplane Co., 8000 Woodley Ave., Van Nuys, Calif.**

Acceptance control facility, $64,130, **Aerojet-General Corp.,** Azusa, Calif.

Metal parts for warhead T45, $1,846,-500, **Aerojet-General Corp.,** Azusa, Calif.

Launching area items, Nike-Hercules, $24,586,276, **Douglas Aircraft Co. Inc.,** 3000 Ocean Park Blvd., Santa Monica, Calif.

U. S. Army Research Contracting Division, Transportation Research and Engineering Command, Ft. Eustis, Va.

Design, construction and testing of two 4-ducted aerial jeeps, $387,831, **Aerophysics Development Corp.,** PO Box 689, Santa Barbara, Calif.

Design, construction, experimentation and testing of two 2-ducted aerial jeep vehicles, $661,441, **Chrysler Corp.,** PO Box 1316, Detroit 31, Mich.

Design, construction and testing of two aerial jeep research vehicles, $653,365, **Piasecki Aircraft Corp.,** Island Rd., International Airport, Philadelphia, Pa.

U. S. Army Signal Supply Agency, 225 S. 18 St., Philadelphia 3, Pa.

Theodolite pulsed light, $54,686, **Motorola, Inc., Riverside Research Labs,** Riverside, Calif.

Services, facilities and materials for six months to conduct a study on advanced "short range" drone aircraft, ground control equipment, launching and recovery equipment, $3,348,685, **Republic Aviation Corp.,** Mineola, N. Y.

Infrared tracker, $58,552, **Barnes Engineering Co.,** Stamford, Conn.

Surveillance drones and related equipment, $1,700,193, **Republic Aviation Corp.,** Mineola, N. Y.

Surveillance drones and related equipment, $1,611,376, **Rheem Mfg. Co.,** Downey, Calif.

Drones and related equipment, modification, $478,818, **Radioplane Co.,** Van Nuys, Calif.

Aerial infrared reconnaisance system, $72,107, **Haller Raymond and Brown Inc.,** State College, Pa.

Design plan of a rocket-beacon wind system, test and inspection procedure; rocket wind vehicle and instrumentation, $133,211, **Convair Div. of General Dynamics Corp.,** Pomona, Calif.

NAVY

Department of the Navy, Bureau of Aeronautics, Washington 25, D. C.

Evaluation of target drones, $774,805, **Beech Aircraft Corp.,** Wichita 1, Kans.

Determination of aerodynamic characteristics of jet flap wing configuration, $217,868, **Fairchild Engine and Airplane Corp., Fairchild Aircraft Div.,** Hagerstown, Md.

Services for correction of defects in and insuring proper use of, operation of, and prevention of maloperation of RMI liquid rocket engines, $27,000, **Reaction Motors, Inc.,** Denville, N. J.

Turbojet engine test equipment design, $35,880, **Adache Associates Inc.,** 880, The Old Arcade, Cleveland 14, Ohio.

District Public Works Officer, Sixth Naval District, Bldg. 13, U. S. Naval Base, Charleston, S. C.

Microwave towers, fuel transfer station and storm shutters for AF Missile Test Center offshore facilities at Grand Bahama Island and Little Carter Cay Auxiliary AF bases, $131,500, **Nat G. Harrison Overseas Corp.,** 5137 N.E. 2nd Ave., Miami, Fla.

Navy Department, Bureau of Ordnance, Washington, D. C.

JATO units with spare igniters, $2,188,-119 **Aerojet-General Corp.,** Sacramento, Calif.

Missile launcher components, $62,659, **Diecraft, Inc.,** Baltimore, Md.

JATO units with straight nozzles, $507,371, **Aerojet-General Corp.,** Sacramento, Calif.

Reproducible drawings for booster grain molds ABL X240 and sustainer grain molds ABL X234, and molds of booster grain Type ABL X240 JATO and sustainer grain Type ABL X234 JATO, $219,825, **The Oliver Corp.,** York, Pa.

JATO units (less fins and thrust structure) and spare igniters, $92,270, **Aerojet-General Corp.,** Sacramento, Calif.

Navy Department, Bureau of Ships, Washington 25, D. C.

Detailed design of water jet propulsion unit, with control mechanism, for a 36 ft landing craft, $28,983, **Western Gear Corp.,** 2600 E. Imperial Highway, Lynwood, Calif.

Navy Department, Officer in Charge of Construction, Potomac River Naval Command, U. S. Naval Gun Factory, Washington 25, D. C.

Turbojet engine test facility at the Naval Air Station, Patuxent River, Md., $128,393, **Southern Commercial Construction, Inc.,** 1341 Pennsylvania Ave. S.E., Washington 3, D. C.

Navy Department, Ordnance Supply Office, Mechanicsburg, Pa.

Test set MK 281-0, and echo simulator MK 315-0, $211,700, **General Electric Co., Missile & Ordnance System Dept.,** 100 Plastic Ave., Pittsfield, Mass.

U. S. Navy Purchasing Office, 1206 S. Santee St., Los Angeles 15, Calif.

Services for movement of jet fuel and aviation gas by barge as ordered by Naval Supply Depot, San Diego, Calif., $171,500, **San Diego Transportation Co.,** Pier 14, San Francisco, Calif.

Services for movement of jet fuel, aviation and motor gasoline by barge as ordered by Naval Air Station, North Island, San Diego, Calif., $150,000, **San Diego Transportation Co.,** Pier 14, San Francisco, Calif.

New Hughes Hot-Shot

GAR-24 infrared seeking Falcon (left) complements GAR-1D Falcon (right), which uses radar guidance.

Latest version of Hughes' Falcon air-to-air guided missile, the GAR-2A is now on operational duty with interceptors of the Air Defense Command.

Designed to be used in combination with the older, radar-guided GAR-1D, the new missile has an infrared guidance system, and homes on heat emanating from enemy aircraft. During test firings at Holloman Air Development Center, the GAR-2A is reported to have knocked down QF-80 jet fighters and TM-61A Matador missiles.

In operation, the missile's IR guidance unit is "slaved" to the target by the radar armament control system of the interceptor before the missile is launched. After firing, the missile's own guidance system takes over, constantly sending signals to the control system to keep the missile locked on its target, regardless of evasive action.

The new Falcon can be fired far below an invader and will climb at supersonic speeds to intercept it. The missile's altitude capability, reports Hughes, is higher than the operational ceiling of any known bomber.

the international scene

News from abroad about rocket and missile activities

BY ANDREW G. HALEY

NOW that we are experiencing the first surge of pride on the successful launching of ASTRONAUTICS, it somehow seems appropriate to take a look at other groups in the far corners of the world which have recently launched astronautical publications.

For example, the French Astronautical Society has a new publication, *Bulletin d'Astronautique* (7, Avenue Raymond-Poincaré, Paris 16e), the first issue of which featured an article on propulsion by Jean Corbeau of the French armament establishment, well known through his extended visits to this country.

The venerable *Journal of the British Interplanetary Society* has been supplemented by the addition of the popular *Spaceflight* (12 Bessborough Gardens, London, S. W. 1), published quarterly at a cost of three shillings an issue. *Spaceflight* is edited by Patrick Moore, the astronomer, and contains articles of general interest and cartoons destined to become drafting-room "pin-up" classics.

Founded Eight Years Ago

Weltraumfahrt (8, Jahrgang, Frankfurt/Main), the organ of the German and Austrian rocket societies, subscriptions to which are available at DM 9.60 a year, is scarcely a new publication, having been founded by its able editor, Heinz Gartmann, eight years ago. However, it is steadily increasing in size and is indispensable to the rocket researcher because of the high integrity of its written and pictorial source material.

The *News-Letter* of The South African Interplanetary Society (P. O. Box 2330, Johannesburg), edited by Mirable Rogers, is rewardingly informative. The South African Society, which has more than 200 members, sponsored an astronautics exhibition at the Witwatersrand Spring Show and more than 120,000 people visited the display!

In Buenos Aires we find the 45-page, closely printed *Revista de la Asociación Argentina* (Viamonte 867), which contains many articles of current interest and is well illustrated, and is now published six times a year under the direction of Teofilo Tabanera.

And, in São Paulo, Brazil, we find the *Boletim* of Sociedade Interplanetária Brasileira (Caixa Postal 6450), edited by Thomas Pedro Bun, and covering subjects such as astrobotany and astrobiology, as well as hardware.

° ° °

On the world scene, meet:

Athelstan Frederick Spilhaus, meteorologist and oceanographer extraordinary, and astronaut plenipotentiary.

Have you ever stopped to realize the debt America owes to the folks from Down Under such as Athelstan Spilhaus, Louis Dunn, Bill Pickering and so many others who have contributed immeasurably to our social and scientific progress in the field of astronautics? Today Dr. Spilhaus is America's No. 1 ambassador to the official scientific organizations of the world because of his position as United States Representative on the Executive Board of UNESCO.

Athelstan F. Spilhaus
"Astronaut plenipotentiary"

Dr. Spilhaus was born in Cape Town and, after receiving his degree of Bachelor of Science at the University of Cape Town, made his way to MIT for postgraduate work. After his marriage in Boston, he returned with his bride to Cape Town and in 1948 received his doctorate in science at the University of Cape Town. He soon returned to the United States and has lived here continuously since, having become an American citizen in 1946. His teaching career has centered successively around MIT, New York University and the University of Minnesota. He was appointed dean of the Institute of Technology of the University of Minnesota in 1949, and in 1954 was named U. S. Member of the Executive Board of UNESCO. He is a charter member of the National Committee for the International Geophysical Year.

Makes Ideal Representative

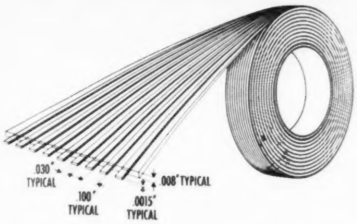
Dr. Spilhaus combines brilliance of mind with felicity of spirit, and so makes an ideal U. S. representative in international scientific conclaves. His felicity of spirit does not admit of any compromise with the effectuation of good and desirable scientific objectives. This point was brought home to me in a most direct and simple manner.

As chairman of the AMERICAN ROCKET SOCIETY Delegation to the VII Annual Congress of the International Astronautical Federation held in Rome last September, I was elected to represent the IAF at the Ninth Session of the UNESCO General Conference at New Delhi in November 1956 for the purpose of obtaining affirmative action on the application of the IAF for nongovernmental consultative status with UNESCO. When I arrived in New Delhi, my reception from most of the important world powers was negative for the simple reason that their scientific representatives refused to recognize the importance of the component societies of the IAF. We received a favorable majority vote largely because Dr. Spilhaus and the American Delegation supported our application.

Since last November, Dr. Spilhaus has espoused the cause of astronautics on many occasions in official and unofficial capacities in the United States and abroad. He has encouraged definitive cooperation between the component societies of the IAF and UNESCO, and was principal speaker at the Spring Meeting of the ARS in Washington, D. C.

In this brief salute it is quite impossible to detail the efforts of Dr. Spilhaus on behalf of astronautics but, of course, this is only a few small paragraphs in a great story.

Flat, Multiconductor Cable Introduced



Dimensions of standard Tape Cable, introduced last month.

A sizable advance in the science of electric circuit design was announced last month by Tape Cable Corp. when it displayed production quantities of its flat, multiconductor cable for the first time. The company expects the polyethylene-insulated, extremely flexible conductor to compete with printed circuits in missile applications.

Essentially, the cable is a ribbon-like film in which are imbedded flat copper conductors 0.0015 in. thick. The conductors are parallel and well insulated from each other.

Properties of Tape Cable cited include minimum cross-sectional area, minimum interconductor capacitance (less than 5 mmf per ft), high tear strength, high flex life, and high resistance to chemical attack. Capacitance value indicates high frequency application.

Its advantages over printed circuits, according to a company representative, include ability to be spliced, flexibility, availability in any length desired and insulation of one conductor from another.

Nine standard sizes, with from 9 through 50 conductors per cable, have been established. Weightwise, a 100-ft roll of 50-conductor cable weighs about $2^1/_2$ lb, an 85 per cent saving over insulated copper cable with the same current carrying capacity, the company stated.

The cable can be stripped of the plastic and all conductors dip soldered simultaneously in a relatively rapid operation.

Supersonic Thunderchief

Swept-forward air ducts prevent F-105 engine from choking.

Air Force's latest "Sunday punch" weapon, the Republic F-105 Thunderchief, outraces the speed of sound. The design of the single-seater bomber includes swept-forward air-intake ducts to prevent the engine from "choking." The new-type ducts also increase flying stability by shattering supersonic shock waves and reducing their effect on the aerodynamically sensitive tail surfaces. The plane, scheduled to join the Tactical Air Command, can carry heavy loads of nuclear as well as conventional weapons on the outside or inside. It is driven by a Pratt & Whitney J-75 turbojet engine of the 15,000-lb-thrust class.

ASTM Forms New Study Committee for Cermets

The American Society for Testing Materials has formed a new study committee in the field of cermets. The committee's first task will be to ascertain the extent of commercial progress in the cermet field, with a view toward establishing test methods and product standards some time in the near future.

All of the cermets being produced at the present time are for experimental usage, with research centered on providing ceramic coatings for such metals as aluminum, magnesium, copper, molybdenum, titanium and beryllium. The practicability of applying ceramic coatings to nonmetallic materials like graphite, glass fiber and other inorganic fiber materials is also under study.

AF Ballistic Missile Div. Officers in Visit to ABMA

A group of Air Force officers representing the Ballistic Missile Div. headed by Maj. Gen. B. A. Schriever recently spent two days visiting at the Army Ballistic Missile Agency in Huntsville, Ala. The visit was one of a continuing series worked out by Gen. Schriever and Maj. J. B. Medaris, ABMA Commander, for exchange of information on the long-range ballistic missile programs of the Army and Air Force.

Denmark Gets U. S. Missiles

U.S.-made guided missiles—the Nike and Honest John—will be added to the equipment of the Danish Army under Mutual Aid Agreements terms.

Radioactive Recovery Technique for Rockets

Recovering a rocket research vehicle, like finding a lost golf ball, is often a time-consuming job. To help researchers with the task of spotting wandering rockets, Era Engineering Corp. of Santa Monica, Calif., has come up with a radioactive recovery technique.

Claimed to be comparatively inexpensive and already successfully employed on the Aerophysics Development Corp. hypersonic test vehicle, the technique involves the use of a radioactive source, contained in an Allen screw about 1 in. long and weighing 1 or 2 oz.

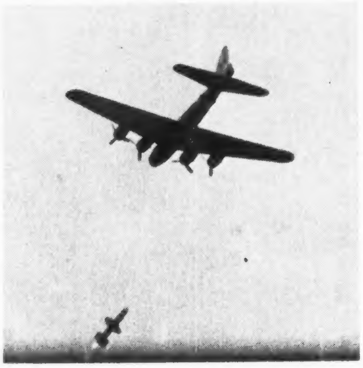
About 10 min before launching, the screw is removed from its protective lead shield and placed in the vehicle, using a 6-ft-long aluminum rod fitted with a magnetized Allen wrench in one end. Normally, impact point of the vehicle is known within an area 10 miles square. Through the use of airborne scintillometers carried in light aircraft or helicopters, the impact area is searched by flying parallel grid lines about 3000 ft apart until the radioactive source is located and marked. Then a recovery crew brings a trailer with the protective container to the spot and removes the source.

Two types of radioactive materials have been used successfully in over 40 experimental flight tests, the company says. The original source was two curies of cobalt 60. Recently, however, four curies of antimony 124 have been employed. Research into use of other materials is now under way.

Intensity of the source is said to be unaffected by the high accelerations encountered in flight or by impact, and the light weight of the source and its small size mean it takes up very little space and has little or no effect on the vehicle's performance.

Use of the radioactive source is claimed by the company to cut the time needed to spot wandering rockets from as much as 3 hours to an average of 30 min. Under normal conditions, the company notes, the recovery crew will receive only negligible, and often immeasurable, amounts of radiation.

Talos Closes in on Prey



Navy surface-to-air Talos heads in for "kill" on a QB-17 drone. Missile has registered kills with reliability and accuracy at distances of 25 miles, and can deliver a nuclear warhead.

General Tire Exec Sees Missile Mail in 1975

Michael G. O'Neil, executive assistant to the president and vice-president of General Tire & Rubber Co., predicted that in 1975 Americans would be sending mail by supersonic missiles, in a recent address to the Los Angeles Society of Security Analysts.

O'Neil noted that, while military spending may decrease by 1975, probably cutting down military applications of the company's Aerojet-General facilities, the division was already working on commercial applications. He indicated that Aerojet now has on its drawing boards the design for a jet engine that could cut flight time between Los Angeles and New York to less than an hour.

Hot Attraction

Hurled from a Sabre fighter at 40,000 ft above the Woomera range, the British de Havilland Firestreak guided weapon "homes" on its target by an infrared system.

Army's Redstone on exhibit in New York's Grand Central terminal.

Redstone At Grand Central

Coming in from the Chrysler plant in Detroit, the Army's 62-ft Redstone rocket arrived at New York's Grand Central terminal on two separate flat cars and entered the main concourse through Gate 16 (the only one believed large enough to admit the missile).

After 14 strain-filled hours, the surface-to-surface guided missile was assembled and set in place for public viewing as the Army's "salute to the International Geophysical Year." In the three weeks it remained on display, the huge vehicle nonplused about 10 million nonchalant New York commuters.

Missile Progress

(CONTINUED FROM PAGE 26)

viously undreamed of by anyone.

At just about this same time, certain new developments made it practicable and feasible to design very-long-range ballistic missiles capable of delivering tremendously powerful warheads. This new phase of missilery included plans for intercontinental missiles as well as intermediate range ballistic missiles which would "only" travel 1500 miles.

If we were to make the most of our opportunities and achieve these new capabilities in the least possible time, it would take a new type of organization. Scientific advisory committees were established, and new streamlined organizations were set up within the Services and within the Office of the Secretary of Defense. My sea cruise was abruptly terminated by the receipt of a dispatch which resulted in my being detached one day and reporting the following day in Washington as Deputy to Eger V. Murphree, the newly appointed Special Assistant to the Secretary of Defense for Guided Missiles.

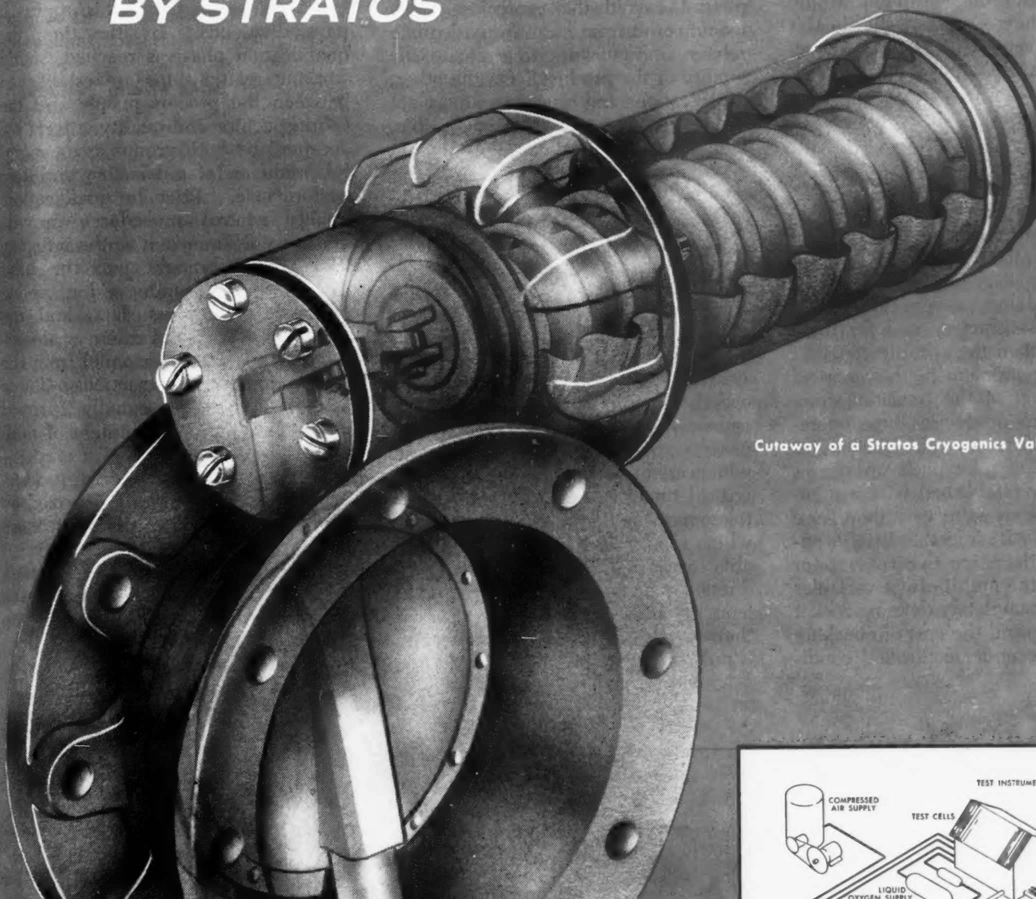
The ensuing year has been a tremendously interesting and productive one. Mr. Murphree brought with him national renown as an engineer and as a research man. He went to work in a quiet but very businesslike manner to insure everything possible would be done to avoid bottlenecks, and to assist those actually prosecuting the various ballistic missile projects, while at the same time keeping a weather eye on the balance of the national guided missile program.

Recently, William M. Holaday, who for the past year has been Deputy Assistant Secretary of Defense for Research and Development, assumed the duties of Special Assistant for Guided Missiles. He is well known to most of you and is carrying on where Murphree left off. His problems will perhaps be somewhat different, because, as the dates of our initial operational capabilities approach and the initial buildup nears completion, we shall find ourselves in the comforting position of no longer being in doubt as to the final result. However, the mechanisms by means of which we handle our multiple approaches to determine the final programs within available resources will require the utmost in judgment and wisdom.

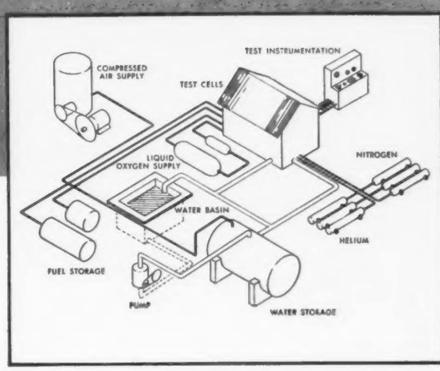
The Services are doing a magnificent job. Progress is, if anything, better than we had any right to expect. The true picture is certainly not one which would give aid and comfort to any potential enemy.

CRYOGENICS VALVES AND PUMPS

BY STRATOS



Cutaway of a Stratos Cryogenics Valve



Schematic of the new Cryogenics Test Facility at Stratos Western Branch

With the facilities and experience to meet the growing requirements of cryogenics, Stratos is at work on a number of interesting projects in the low temperature field. Besides a basic background in the aircraft accessories field, Stratos engineering department includes specialists in cryogenics—men who have broad experience with gases at very low temperatures and with liquefied gases.

Among the cryogenic facilities at Stratos is a test installation recently completed at the Western Branch plant Manhattan Beach, Calif. This facility can test valves up to 12″ diameter and achieve flow rates above 11,000 gpm.

Inquiries on valves, pumps, controls and systems are invited.

STRATOS

A DIVISION OF FAIRCHILD ENGINE AND AIRPLANE CORPORATION

Main Plant: Bay Shore, Long Island;
Western Branch: 1800 Rosecrans Ave.,
Manhattan Beach, California.

Rocket Motors

(CONTINUED FROM PAGE 44)

of contained carbon black, because pilot plant experience had indicated this would yield a satisfactory product. Careful analysis of production experience resulted in an increase in the allowable variation to a value of ±13.6 per cent of the contained carbon black, making possible substantial cost savings, since the black content of the copolymer can be controlled in the master batching operation within this range, and very few batches now require adjustment of the black content.

Similarly, the original specification for a two-ply restrictor was based on development experience which indicated that such a restricting system was required to obtain proper adhesion of the plates to the propellant grain. Further development work, done after initiation of production, indicated that a single-ply restrictor of slightly modified composition would be equally satisfactory and far more economical than the two-ply type.

The basic problem in this area, of course, is that of the transition from pilot plant to production-type operation. Specifications and procedures growing out of pilot plant operations are generally established with a minimum of analysis as to why they were satisfactory. It is immediately apparent that there are two reasons for this. First, the multitude of variables involved in completely defining rocket performance, and the cost of checking each variable under controlled conditions (not to mention the time involved), make it impracticable to consider a complete definition of specifications and procedures during pilot plant operations. Second, it is often necessary to observe large-scale operations over a period of time to accrue sufficient data to justify a change in specifications.

The production planner is thus faced with an uncomfortable dilemma. On the one hand, specifications and procedures must be sufficiently complete to avoid the confusion which would result from lack of an adequate reference framework to evaluate the quality of the product. On the other, specifications and procedures must not be regarded as sacred and inflexible, lest the result be continuing high process losses and, in turn, high costs and low productivity.

Should Accompany Development

Selection and refinement of quality control methods should logically keep pace with the development of the rocket motor itself. The optimum situation is found in a continuous, orderly growth of quality control procedures concurrent with development progress. Problems are thus avoided which might occur later on at a more critical time, as a result of unrealistic tolerances or ambiguous statements which render the specification unsuitable for use as a procurement or production document. Common problems of this type are easier to avoid than to correct after the specification is published. In our organization, the Quality Control Planning Section renders a major service to the development group in the preparation of specifications and procedures.

In pilot plant operations, the quality control inspector works as a trained observer who identifies and reports deviating parts, materials or processes. He neither "accepts" nor "rejects" material, as he would do in a routine production operation. On development programs, responsibility for these decisions is vested in the project engineer. We have found this approach pays dividends. By the time the qualification phase is reached, sound working relationships are established between the process people and the QC inspectors, and quality criteria are accepted by both groups as meaningful predictors of satisfactory end-item performance. Prior to qualification, quality control procedures provide necessary assurance as to the integrity of materials brought into the pilot plant; insure accurate and complete recording of process data; and describe the nature and extent of departures by operating personnel from the project engineer's instructions. These functions have repeatedly proved valuable in the interpretation of end-item test results.

It is not unusual for initial production operations to be characterized by high rates of loss. In large part, these may be attributed to three factors:

1. Effects of process variables which cannot be evaluated completely at the pilot plant level because of either the scale factor or press of time.
2. Unnecessarily tight process specifications or procedures.
3. Unnecessary process elements or restrictions.

Blender Was By-Passed

The first two have already been discussed. Several interesting examples of the third were encountered in the M-15 production program. In the initial production operations, the oxidizer was ground, analyzed for particle size, and then blended to a uniform particle size distribution. Operating experience soon indicated, however, that the blending operation was unnecessary, inasmuch as particle size distribution was a secondary factor in controlling the ballistics of the finished propellant, and that the same degree of control of end product ballistics could more economically be exerted at a subsequent point in the process. It was thus possible to bypass the blender, with substantial savings in both direct operating and equipment maintenance labor.

Another example was the reworking of scrap propellant. During initial production operations, all propellant

Operation Bullet

Maj. John H. Glenn, USMC, piloting the F8U-1P Crusader in which he set a new national speed record between Los Angeles and New York, flying the 2456-mile route in 3 hours 23 min. During flight, cameras in the fuselage photographed the country coast-to-coast.

trimmings, propellant grains rejected for physical defects, and propellant mixes rejected for reasons of burning rate were consigned to the burning ground. It has been found, however, that all three categories of rejected propellant can be reworked with new ingredients to yield a propellant mix which cannot be distinguished from that made from 100 per cent virgin materials. While there is probably a limit to the amount of scrap propellant which can be so used, it is well beyond the normal percentage of scrap propellant materials encountered.

Usability Time Is Short

Many of the restrictors and adhesives used with solid propellants are materials whose time of usability after preparation is relatively short. Careful study of the requirements of the M-15 has made it possible to reduce and in some cases eliminate the use of materials with short pot-life. Because loss experience in production operations from the use of materials having short pot-lives can run as high as 40 or 50 per cent of material which may cost as much as $20 per gal, there is considerable incentive to eliminate as many applications as possible. Although such short pot-life materials account for only a few cents of the total cost of the M-15, the possibility of production delays on the line resulting from inadequate phasing of the operations utilizing this material makes it well worth while to reduce the number of such operations to the bare minimum.

Improvements in the basic process itself, resulting from development work continued during production phase-in, can be expected to contribute substantially to lowering the rejection rate. Consider the case of the burning rate of finished M-15 propellant: More than 12 important variables affecting the burning rate of finished propellant were identified during pilot plant development. Some were interdependent, which further complicated the problem of process control. However, initial production line experience pointed up the fact that for all practical purposes the burning rate could be controlled by controlling process mechanics at the mixing stage, the burning rate being quite susceptible to small differences in mixing intensity and duration.

Quite precise control of burning rate at this stage of the process was achieved by the introduction into the propellant formulation of a burning rate depressant. This made it possible to obtain complete control of the burning rate of the finished propellant at the mixing stage, by controlling the mixing time. The chart on page 44 shows the relationship of mixing time and burning rate for two propellant formulas—one with and one without this depressant. It clearly demonstrates the decrease in sensitivity of burning rate to mix time conferred by the depressant.

The accurate prediction of ballistic performance early in the process can have an important bearing on rejection rate, particularly if it is possible to predict the burning rate in sufficient time to allow in-process correction of off-specification ballistic performance. Strand burning rates are commonly used as indicators of ballistic performance. Initially, however, the time lapse involved in obtaining strand burning rate on cured samples of M-15 propellant was nearly a full day.

Comparison of the burning rates of cured strands with those of uncured strands showed that the 95 per cent confidence levels of accurately predicting thrust from uncured strand burning rates falls within the same limits as those for cured strands. Therefore, using uncured strands, it is now possible to obtain burning rate data on propellant mixes before they leave the mixing area. This makes it practical to adjust the burning rate by remixing the mix from which the burning rate sample was taken, and to make process corrections on following mixes without interrupting production flow.

Reduces Propellant Scrap

The combination of propellant rework capability, positive control of burning rate at the mixing stage through the use of the burning rate depressant, and remix permits a very substantial reduction in propellant scrap. In fact, it is reasonable to predict the complete elimination of process loss, except for contaminated scrap propellant, such as floor sweepings. The net effect of all these process improvements during initial production operations has been a 14-fold reduction in the rate of rejection of materials from the production line during the first seven months of operation. The total rejection cost as a percentage of deliverable unit cost is now, and has been for some time, under 1 per cent.

Process equipment itself may prove a problem source in propellant operations. Because the process necessitates remote operations in many cases, the equipment may have many automatic devices. In addition, the measurement of critical process variables during the operation of the machine may require protective devices, alarms, deluge control and a multitude of related items not ordinarily found on industrial equipment. These factors all directly affect maintenance costs, as well as equipment reliability.

Problems with process equipment of the more sophisticated type are expected in a new process during shakedown. After the reliability of the equipment is established, records should be maintained to focus attention on substandard equipment and to forecast life cycles of wearing parts. In analyzing service received from our mixing equipment, it was evident in the early production stages that life of the dispersion blades was lower than could be tolerated. These blades were cored for cooling water flow and were failing, apparently because of low section modulus. Redesign improved blade life from 300 mixes to upward of 4000 mixes per installation.

More far reaching problems in processing propellant can result from defective safety devices. Several changes have been made in vacuum control and indicating devices on blocking and extrusion presses to insure reliable operations. Clogging of vacuum ports and gage lines has been identified through operating and equipment records as a critical maintenance factor.

In summary, Phillips' experience in the production of the M-15 JATO points to the merit of Pope's adage: "Just as the twig is bent, the tree's inclined." In other words, look early in the development process for means to insure control of factors which will affect productivity, material cost, process loss, manpower requirements and equipment reliability.

Murphree: Bell Developing Army Anti-Missile Missile

Bell Telephone Laboratories is handling research and development work on the Army's anti-missile missile, dubbed Nike-Zeus, Eger V. Murphree, president of Esso Research and Engineering Co., said recently.

Murphree, who earlier this year left his post as Defense Department missile "czar" to return to Esso, made the disclosure after revealing the existence of work on the weapon in a talk to the Overseas Press Club in New York.

Neither Bell nor the Army Research and Development Office in Washington had any comment to make about Murphree's disclosures.

Murphree also said he thought Douglas Aircraft Co. might be "doing some work" on designing the airframe for the anti-missile missile, but added that he was not absolutely certain of this. Douglas officials also declined to comment on the statement.

in print

A Space Traveler's Guide to Mars, by I. M. Levitt, Henry Holt & Co., New York, 175 pp., 14 illustrations. $3.50.

Reviewed by Kurt R. Stehling
Naval Research Laboratory

This interesting little volume has a provocative title. At first glance one might think this is a description of a space ship trip to Mars. Instead, it is a popular astronomical treatise on Mars, with a little space flight thrown in. These days, most astronomers permit themselves a modest, discreet indulgence in space flight speculation now and then. Dr. Levitt, in contrast, has been an enthusiastic proponent of space travel and has written and lectured widely on the subject. His Fels Planetarium has also served him as a platform for this.

The first chapter, "Men Against Mars," describes briefly Wernher von Braun's book on the "Mars Project" and a British project for a "Martian Probe Rocket." The reader is then led into the environment of an observatory with visitors looking through a large telescope at Mars. The description of the astronomer's patience with the crowd and the various activities in the observation area obviously come from Levitt's own experiences.

After this bucolic introduction, the author gets down to business in the remaining seven chapters and describes the planet Mars. The text now becomes a highly popular astronomical treatise on such Martian features as its appearance, motion, seasons, climate, moons, surface detail, atmosphere and life.

There is nothing new here when compared with other texts on Mars. However, the author has drawn on many references, some rather obscure, and skillfully synthesized all of them into a connected story.

Levitt concludes from his own experience and that of other observers that the Martian "canals" are an optical illusion and do not exist. This must have taken some courage, for he strives diligently throughout the book to show that Mars is not as dismal a spot as has been stated by other astronomers. After all, if a space traveler is to go to Mars, he ought not to find an airless desert.

Says Mars Has Atmosphere

Thus, while Levitt rejects the canals as nonexistent, in the next breath, so to speak, he states that Mars has a tenuous but still respectable atmosphere and has a primitive but well-developed vegetable life. He admits, however, that animal life's existence is not proved.

In the last two chapters, the author blasts off from the solar system and describes the beginning of the stars and the solar system and life in the universe. He agrees with the not unreasonable thesis of other astronomers that there may be life—and very advanced life at that—in other parts of the universe. This subject is always a good one to broach to an orthodox theologian for interesting and calm debate.

Two appendices discuss a space flight timetable: Vanguard by 1957–1958, the "television" satellite by 1960, an instrumented satellite (a super-Vanguard?) with animals as space pioneers by 1964, a manned satellite in 1968, a space station by 1978–1980 and in 2000, "trips to the moon and planets are contemplated." The author then moves on heroically

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to a description of his "Martian calendar." The last appendix describes the purported beginnings of life on earth, as a result of rather complicated physical and chemical forces and interactions.

The book is one of the most readable and interesting accounts of Mars this reviewer has read and is a must for the space flight enthusiast who wishes to be well rounded.

The Making of a Moon—The Story of the Earth Satellite Program, by Arthur C. Clarke, 200 pp., Harper & Brothers. $3.50.

The International Geophysical Year officially began on July 1. The climax of this world-wide scientific effort will be the launching of man's first artificial satellite. The first satellite test vehicles have already been fired, and the satellite itself will be launched some time in 1958.

Meanwhile, the world is waiting. This one event—a scientific attack on the space barrier that promises to free man from his gravity-bound earth—has stoked humanity's collective imagination with a vigor that far surpasses anything the science-fiction writers have been able to dream up. And therein lies a story—or rather, a valuable market for a story, any nonfiction story on the U. S. earth satellite program, popularly known as Project Vanguard. Now is the ideal time, since, for some reason, most people prefer to be in on an event *before* it actually happens. And the information is available, if not easily obtainable.

Former BIS Chairman

It is likely that this thought also crossed the author's mind. Arthur Clarke is a professional writer, better known, perhaps, for his science-fiction than his nonfiction. He is also a fellow of the Royal Astronomical Society and former chairman of the British Interplanetary Society. But, if a straightforward story of Project Vanguard is what Clarke was aiming at, then he has missed his target.

In only four of the book's 19 chapters can Project Vanguard be considered the principal topic. These are: Chapter 6, The Vanguard Vehicle; Chapter 7, The Satellite Builders; Chapter 9, Moonrise in the West; and Chapter 10, The Moon Watchers. In the first five chapters, Clarke concerns himself for the most part with background and personal reminiscences and considerations of rockets and satellites in general.

In the last nine chapters, the author is carried away by post-Vanguard conjectures, e.g., satellites weighing several hundred pounds, which the author believes will be established and recovered within the next decade; interplanetary rockets; manned space vehicles; satelloids; space television stations; way stations for interplanetary travel; and so on.

Asks for an Argument

Chapter 8, incidentally, is devoted to a generalized consideration of experiments that might be carried out using a space laboratory such as the artificial satellite. When the author discusses ionospheric experiments, as he does on p. 117, he is asking for an argument from those better informed than he, the ionosphere researchers.

To begin with, Clarke ignores the rather large amount of valuable information about the ionosphere these men have already gathered through use of high altitude research rockets. He goes on to say: "A small radio transmitter in the satellite, especially if it constantly swept through a wide band of frequencies, would give us far more detailed information about the structure of the ionosphere." Not only is this impractical; it is not necessary. Use of a constant frequency will provide all the information that is needed. And, of course, Clarke's conception of the ionosphere as electrified layers is outmoded, but this is a minor point.

Most of the author's few errors are minor. Items: On p. 84, his statement that "there is no hope for great improvements [over alcohol and liquid oxygen as chemical propellants] in the near future" will certainly be argued by hydrogen-fluorine and solid propellant advocates; and on p. 93, his description of the separation of the Vanguard's nose cone can best be classed as poetic license.

On p. 51, however, the author propagates a major misconception when he refers to the gradual slowing-down of the first satellites as the action from which "we hope to calculate the air density." This is not how the satellite experimenters plan to obtain air density measurements. More important, the satellite does not slow down; it will actually speed up as it draws closer to earth.

Look Vainly for Explanation

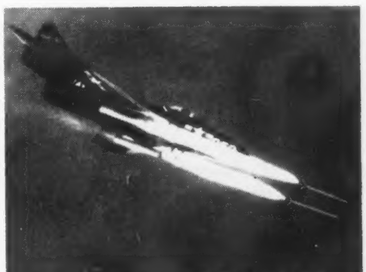
And, of course, it is annoying to the reader to look vainly in Chapter 4 (as directed by the author on p. 29) for the explanation of a questionable statement made on p. 28. It is also annoying to find on p. 107 that the final Vanguard test vehicle has been fired when all official indications would have us believe otherwise.

The full story of the U. S. earth satellite program has yet to be written. Clarke has glossed over or left out most of the technical—but interesting—details of the problems and accomplishments involved in producing the first artificial earth satellite. He writes practically nothing, for example, about the guidance and programming of the satellite vehicle; of the fabrication and coating of the satellite itself; nor of the precision needed for the production of both units. Then there is the experimental instrumentation, with its requisite miniaturization; the internal structuring of the satellite; the clever thermal switching arrangement; the involved testing and check-out program; the procurement and subcontractor set-up; the collaboration among all those involved; the setbacks and, more important, the successes encountered all along the line. All this is part and parcel of the story that is Project Vanguard—the story of the first artificial satellite.

By leaving all this out, Clarke has managed to write a fast-reading book that will undoubtedly prove of interest to the space novitiate. But to those with a hunger for meat, he offers only warmed-over bones.

—M. Y.

Scalp-Seeking Zunis



U. S. Navy photograph

Aerial firing of two Zuni rockets from F9F Cougar. The Zuni, a 5-in.diam, folding-fin, solid propellent rocket, will be used as an air-to-air and air-to-surface missile on Navy fighters and attack-type aircraft.

Movieland Lighting Device To Measure Sky Brightness

An electronic device which Hollywood has been using to measure light values accurately will in the near future measure brightness of the skies. Called the spectra brightness meter, it will accompany Maj. David G. Simons of Holloman Air Development Center when he makes his scheduled ascent in an Air Force balloon beyond 100,000 ft into outer space. The instrument was developed by noted Hollywood director and photographic authority Karl Freund, who heads Photo Research Corp.

from the patent office

BY GEORGE F. McLAUGHLIN

Refractory Coat for Jet Engine Walls

One difficulty which faces the designers of jet engines is the tendency for combustion chambers to burn out because of erosion and high temperatures.

When a refractory coating is applied to the chamber wall before operation of the burner, it is effective for only a short time, after which it disappears. This may be due to erosion, vaporization of the coating because of the high operating temperature, or differential expansion between the chamber wall and the coating when the motor is started or stopped and a substantial temperature change takes place.

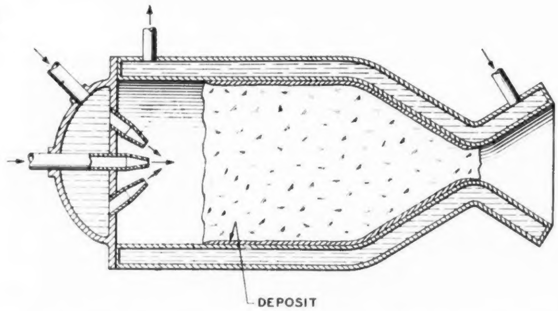
To overcome this difficulty, it is desirable to build up and maintain or renew the coating endogenously during operation. This is accomplished by continuously injecting into the chamber an oxidant (such as liquid or gaseous oxygen, ozone or peroxides) and a fuel comprising a substance which burns in the oxidant to form a refractory solid material. This material is deposited and built up or renewed in the chamber to maintain the protective coating.

The fuel can comprise readily combustible organic and inorganic silicon compounds which burn in oxygen to form a deposit of silica. Examples of such compounds are tetra-ethyl orthosilicate, tetra-methyl orthosilicate, triclorosilane, dichlorosilicate, and other combustible halogenated silanes or esters of orthosilicic acid, or of their derivatives.

In one example of how this method was employed, a water-cooled jet motor was operated on a test block by introducing monomeric tetra-ethyl orthosilicate to a header, from which it was discharged into the combustion chamber through nozzles arranged in a ring at one end of the chamber. At the same time, oxygen was introduced and injected centrally into the chamber through a nozzle centered within the ring of nozzles.

At an oxygen-to-fuel ratio of 0.904, the motor was operated for several runs lasting between 18.4 and 42 sec. In each run, a coating of silica was built up and maintained on the previously uncoated wall of the chamber.

Operating internal combustion burners of the jet motor type (Patent No. 2,794,316). Paul F. Winternitz, assignor to Reaction Motors, Inc.



Sectional view showing protective deposit on inner wall of combustion chamber.

Spin Launching of Rockets

An elongated missile propelled through the air has a tendency to "tumble." Instead of proceeding along its trajectory with its longitudinal axis parallel to the line of flight, the axis might rotate erratically with respect to the line of flight. To reduce this tendency and improve its stability, a method of spin launching and spin stabilizing has been devised.

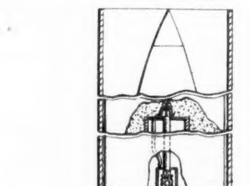
Initial spin is imparted to a rocket in a launching tube or bed so that the rocket will leave the launcher in a spinning condition. This provides gyroscopic stabilization of the longitudinal axis of the rocket upon entering the acceleration phase of its flight trajectory. To this end, a spin motor of the solid fuel type is used. The motor can be quickly and easily recharged, and the fuel is arranged to obtain optimum combustion efficiency.

In one preferred arrangement, the spin motor comprises a motor body adapted to be coupled with a rocket; a fuel charge supported and arranged in the body so as to insure a high degree of combustion efficiency; and an ignition system coordinated to ignite the motor charge and the rocket propellant in proper sequence.

The rocket has a rearwardly disposed combustion chamber, with the propulsion charge arranged in the usual manner. Gas from the charge, when ignited, is released through several nozzles. The spin motor includes coupling means for connecting the rocket and motor together, and an exhaust tube to carry off the rocket gases, spin motor ignition and the spin motor.

The coupling has a number of conventional key slots evenly spaced around the flange at the rear of the rocket. These slots receive a like number of keys provided around the edge of the blast tube extending through the spin motor. The end of the blast tube, when coupled with the rocket, encloses the rocket nozzles. This placement ducts the released gases through the blast tube and out of the exit opening as the spin motor causes the rocket to rotate prior to launching.

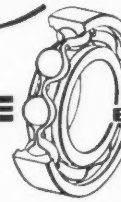
Reaction device (Patent No. 2,792,-758). John H. Bach, Vaughn E. Peak and Karl W. Maier, assignors to Northrop Aircraft, Inc.



Spin launched rocket (left), and a cross section of the spin motor in the launching tube prior to firing.

FACTS

about

NEW DEPARTURE  **BALL BEARINGS**

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Missile Market

(CONTINUED FROM PAGE 54)

bentures. In addition, General Tire is thinking of raising $15–20 million within the next several months, and Sperry Rand indicated it will tap the capital market with a large issue in the near future.

Last month we discussed Douglas Aircraft and General Dynamics. An appraisal of the other two companies we included in the group of large and well-diversified leaders in their respective industries who are closely associated with the rocket and guided missiles field follows:

General Tire & Rubber—Unlike the other companies in this group, General is only indirectly a participant in the missile business, but its 87.6 per cent ownership in one of the leading firms in the industry, Aerojet-General, makes it of interest.

Its other activities are widely diversified, ranging from its position as the fifth largest domestic rubber fabricator, through its RKO Teleradio Pictures subsidiary, to its 72 per cent voting interest in A. M. Byers, a wrought iron producer. About 37 per cent of its 1956 sales came from its tire lines, with a similar percentage from Aerojet.

Record earnings are projected for the current fiscal year, and increasing diversification points to continued future earnings growth. Directors have approved a 3-for-1 split and have raised fractionally cash dividends on the new stock. Some stock dividends will undoubtedly continue to augment the cash payments. Various classes of preferred stock and warrants are also available for investment.

Sperry Rand—This well-established and diversified electronics firm is a leader in the development of missile systems. The built-in safety factor here, without sacrificing any growth potential, is the company's outstanding position in nonmilitary fields. This is especially true in the area of office automation, where its Univac data processing system is an important factor. The Sperry Div. is the prime contractor for the Navy's Sparrow missile.

Gradual earnings improvement is anticipated as the consolidated company, the result of a 1955 merger between the former Sperry Corp. and Remington-Rand, is able to increase its share in a market in which it competes with such giants as IBM, and its profit margins. Nongovernment sales accounted for 59 per cent of total volume and 64 per cent of net income before taxes in the fiscal year ended March 31. Present quarterly dividend of 20 cents is a minimum expectation for the near future.

Market Letter Gleanings

Douglas Aircraft—"We consider the common stock an attractive commitment . . . Douglas offers the stockholders one of the better aircraft values today." (Orvis Brothers & Co.)

Sperry Rand—"Purchase advised." (Moody's)

Thompson Products—". . . at current levels is extremely attractive." (Green, Ellis and Anderson)

Northrop Aircraft—". . . a good candidate for income and appreciation." (Freehling, Meyerhoff & Co.)

Boeing—". . . continues to look very attractive." (Goodbody & Co.)

General Dynamics—"Should prove an attractive purchase on general market weakness." (Arthur Wiesenberger & Co.)

Among "currently attractive securities," Bear Stearns lists Lockheed Aircraft and Olin Mathieson.

"We believe there are two aircrafts which can be bought at this time: Boeing and General Dynamics . . . We still believe commitments in either General Tire or its almost wholly owned subsidiary, Aerojet-General, is one of the best ways to participate in the missile field." (Hemphill, Noyes & Co.)

General Dynamics, Liquid Carbonic Corp. discussing merger . . . General Tire Board votes three-for-one split on common, increases dividend on new stock.

Financial Briefs

Six-month earnings:

	1957	1956
Chance Vought	\$1.95	\$1.35
Reaction Motors	0.75	0.41
Douglas Aircraft	4.86	3.46
Thompson Products	2.96	1.72
Thiokol	1.34	0.85
General Tire	3.36	2.41
Boeing	2.47	2.22
General Dynamics	2.32	1.40

Wage War on Jet Engine Flameout

Jet engine flameout—the terror of pilots—appears to be well along the road to obsolescence. Two recent developments promise to push the problem well around the bend.

The first, announced recently by Curtiss-Wright, involves the use of aluminum-based pyrophoric fuels that spontaneously ignite in contact with air. Emergency reignition systems developed by the company simply discharge a small quantity of the fuel into the engine's combustion chamber.

"Invariably" successful tests at sea level and at simulated altitudes up to 52,000 ft were cited by C-W. It predicted the system can be used at any altitude a turbojet can reach (about 120,000 ft). The tests were conducted at the Navy BuAer Aircraft Engine Lab in Philadelphia.

The new pyrophoric fuel, a mixture of aluminum trimethyl (ATM) and aluminum triethyl (ATE), has an energy content of about 19,000 Btu/lb, or slightly above those of conventional jet hydrocarbon fuels. It burns somewhat like kerosene, emitting an orange flame and a small volume of nontoxic smoke. Reliable spontaneous ignition has been demonstrated between −40 F, its freezing point, and 400 F.

The other antiflameout development is a platinum-alloy rod (or tube) smaller than a cigarette. It boasts no electrical connections or moving parts, operating instead as a catalyst for jet-fuel combustion.

Platinum-alloy reigniter for flamed-out jets.

Measuring $^1/_4$ in. in diam, the Instalite rod is mounted in a 1-in.-diam screw or flange holder. Installed, it protrudes $1^1/_2$ to 2 in. into the engine's combustion chamber. Up to four such devices may be mounted in each engine. High retentivity of heat gained from the engine's normal operation further promotes reignition.

Manufactured by Charles Engelhard, Inc., of East Newark, N. J., Instalite is reported to be standard equipment on the Bristol Britannias of the British Overseas Airways fleet. Seven major American jet makers are trying to apply it to their products, the company said.

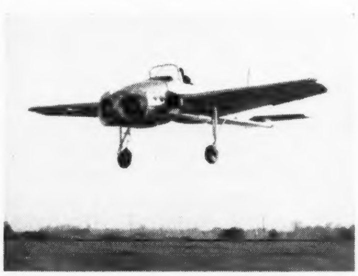
Giant Radio Telescope Nears Completion in England

The new giant radio telescope developed for the University of Manchester in England is reported nearly ready for use. Said to be the most sensitive short-wave radio receiver-transmitter ever built, it is a steerable radio telescope capable of remaining fixed on one point in space, irrespective of the rotation of the earth or of the earth's movement around the sun. The 2000-ton telescope is expected to improve immensely on the capabilities of the fixed reflector which has already made it possible for British scientists to study the daytime sky and map the nebula of Andromeda.

X-2 Reached 126,000 Feet

The Air Force has finally announced the altitude mark set by the ill-fated Bell X-2 rocket plane in which Capt. Milburn Apt, test pilot of the ship, lost his life last September—126,000 ft, or almost 24 miles. Capt. Apt was killed when the plane went out of control and crashed after reaching the record altitude.

Bell X-14 Flight Tested



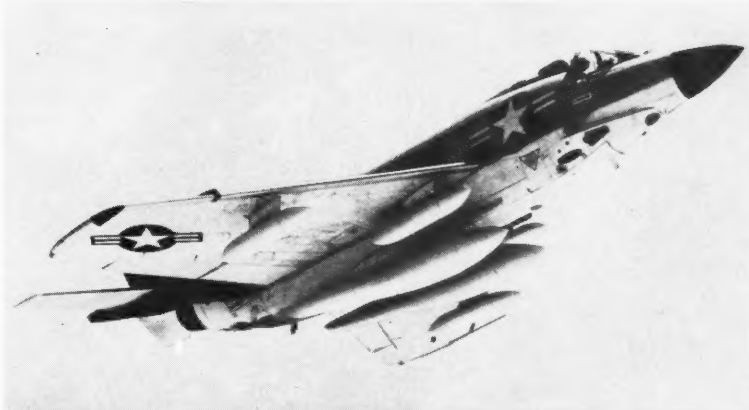
Newest jet VTOL plane, Bell's X-14, in test flight.

Bell Aircraft Corp.'s jet-powered VTOL airplane, the X-14, has successfully completed initial flight testing, the Air Force announced last month. Powered by two British Armstrong-Siddely jet engines, the X-14 is designed to take off vertically in a conventional horizontal position, shift to forward flight and land vertically.

The X-14 differs from so-called "tail-sitter" VTOL aircraft in that it can operate without the need for ground handling equipment to position it for take-off. Thrust diverters behind the engines direct the jet exhaust toward the ground to lift the plane into the air. For forward flight, the thrust is redirected toward the rear.

The experimental plane has a 34-ft wingspan and is 25 ft long and 8 ft high at the tail.

Rocket Launchers for McDonnell Demon



Aero 7D rocket launchers for the U. S. Navy are in full-scale production by Be-Ge Mfg. Co. Four launchers are attached to the wings of the McDonnell Demon F 3H2N. Each launcher can carry nineteen 2.75-in. folding-fin aircraft rockets. Auxiliary fuel tanks are carried under the fuselage.

New Wind Tunnel Placed In Operation at Rocketdyne

Engineers at Rocketdyne Div. of North American Aviation, Inc., are probing rocket engine performance on the fringes of outer space by means of a new wind tunnel installed at the company's Los Angeles plant. The tunnel, one of the first to be devoted to high altitude rocket studies, simulates the rush of exhaust gases from rocket engine thrust chambers by pulling high speed air through a vacuum.

Advanced instrumentation techniques in the tunnel are said to record thrust, flow and pressure measurements with accuracy from five to 10 times that of conventional wind tunnel equipment, providing laboratory insight into the flow patterns of fast rocket exhaust gases.

The tunnel, jointly financed by Rocketdyne and the Air Force, was built at a cost of more than $650,000.

New RCA Noise Machine May Be Used to Test Missile Parts

Radio Corp. of America's new high intensity noise system, capable of producing up to 145 decibels, close to the noise a jet plane makes at take-off, may provide a means for noise testing of missile and jet aircraft components.

The noise-maker is available in two models, one providing a 6 by 3 by $1^1/_2$ ft test chamber, and the other a smaller version with a much smaller test area. It is said to be capable of reproducing the noise spectrum of rockets and jet engines, thus permitting environmental testing of missile and aircraft parts.

Patrick AFB Hit By Labor Strife

The aftermath of a 21-day strike from May 21 to June 14 at Patrick AFB is still being felt at the missile test center, with necessary construction work hampered by a "cold war" being waged by Local 79 of the International Brotherhood of Teamsters and an association of contractors at the base.

While the direct effects of the strike on the missile program are difficult to assess, the dispute is being watched carefully in Washington because defense construction at Patrick has been assigned "crash program" priority by the Corps of Engineers.

Nike-Ajax Test Score: 13 'Kills' in 14 Shots

A score of 13 "kills" in 14 firings was chalked up by Nike-Ajax missiles in a series of exhaustive tests by an Army Air Defense Command Battalion at the Red Canyon Range, part of Fort Bliss, Tex. In the tests, the missiles were fired against low-flying targets employing evasive tactics. Official confirmation of the test results came after verification of recorded data.

One of the kills was recorded at an altitude of only 3000 ft, actually only about 1000 ft over the floor of the range. In the tests, radio-controlled drones came in over the range in some of their approaches at the minimum altitude invading aircraft could fly to carry out low-level attacks and in some instances were orbited over the range at the lowest altitude at which they could fly and still remain within radio control.

IGY notes

IVAN: He shoots the sun . . .

. . . as does NRL's Robert J. Boye.

A Russian report indicates that personnel at the Sternberg State Astronomical Institute are already hard at work on numerous IGY projects. The basic problem with which the institute is concerned is that of the earth's rotation, but institute scientists will also conduct studies of solar activity on the sun's surface and of gravity forces on land and sea. P. Kozhevnikov, the researcher pictured above, is testing the celostat of a tower solar telescope at Sternberg Institute.

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The Navy's Minitrack Test Facility at Blossom Point, Md., reports that its earth satellite radio tracking station has picked up signals from the moon. No special intelligence was ascribed to the message, since the signals originated from the Army Signal Corps' giant radar transmitter "Diana" at Fort Monmouth, N. J. Purpose of this "moon talk" is to test and calibrate the different satellite tracking stations, both official and amateur.

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Astronomers at the Naval Research Laboratory in Washington, D. C., will be taking pictures of the sun every 30 sec each day for the next 18 months. This project, part of the laboratory's IGY activities, is being carried out by members of its Radio Astronomy Branch, who have been studying radiation from the sun, moon, stars, planets and interstellar space during the past 11 years. They use a Lyot monochromatic heliograph which automatically and continuously records on 35-mm film events in the hydrogen alpha line of the solar spectrum.

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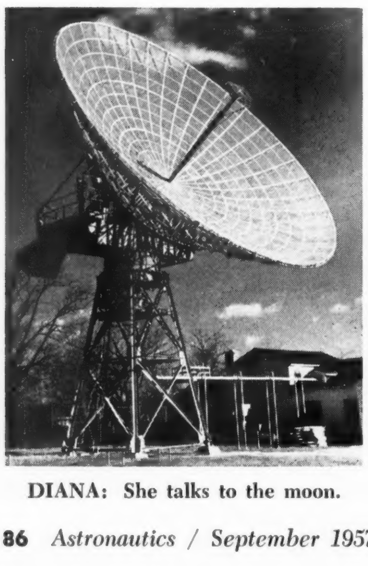
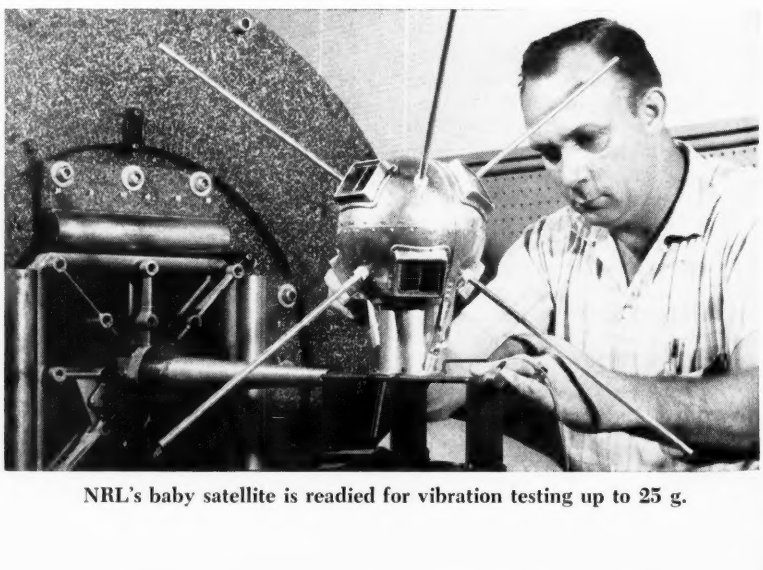
A tiny magnesium sphere, 6.4 in. in diam and weighing 4.5 lb, will be launched from each of the last four test vehicles used in development of the Vanguard earth satellite vehicle.

These test balls, already dubbed "baby earth satellites" by the press, will measure the effectiveness of the third-stage rocket. Defense Dept. spokesmen consider it "highly un-



DIANA: She talks to the moon.



NRL's baby satellite is readied for vibration testing up to 25 g.

likely" that the spheres will orbit the earth, particularly those carried in the fourth and fifth test vehicles, although there is a theoretical possibility that this may occur.

The third test vehicle will probably be fired early this month, although it has been scheduled to go a month earlier. Since six weeks to two months usually elapse between tests, the fourth vehicle, carrying the first test sphere, should be ready around November.

The tiny spheres will simulate the fully instrumented 20-in., 21.5-lb satellite whose launching will culminate the Vanguard project. Plans for Vanguard have always called for use of the baby spheres as test payloads to provide engineering data on the performance of the launching vehicle and related tracking equipment. Equipped with antennas and Minitrack radio transmitters, the spheres will permit velocity measurements before and after ejection.

A temperature recorder may also be carried in the test sphere. Also, half a dozen solar batteries of the type that may power later satellites will be carried on the skin of the test device for evaluation purposes.

Because of the large quantities of test instrumentation to be carried in each stage of the test vehicles, scientists doubt if the altitude necessary to put the small spheres into orbit can be attained. This weight penalty will be especially great in the fourth and fifth test vehicles, tapering off as the test program reaches its climax.

Optical tracking of the test satellite does not seem possible, it was reported.

The first and second test vehicles fired at Cape Canaveral, Fla., were essentially Viking rockets, the second with Vanguard's third-stage rocket mounted on top. Both vehicles were highly successful. The third test vehicle, designated TV-2, is the first to bear the true form and weight of the anticipated Vanguard vehicle, although in the test the second and third stages will be simulated. The fourth test vehicle, with the test satellite, will be the first trial for all three stages operating in planned sequence.

14 Guggenheim Fellows Appointed for 1957-1958

Fourteen Daniel and Florence Guggenheim Fellows have been appointed for advanced study in jet propulsion, rockets and flight structures at Princeton, Cal Tech and Columbia for 1957–1958.

Those chosen for study at Princeton are Ching-Sheng Wu, Princeton, N. J.; Rudolph J. Swigart, Bay Shore, N. Y.; and Wilmot H. Webb, Bethesda, Md. Henrik J. Hagerup, Cambridge, Mass., and Martin Sichel, Albany, N. Y., were reappointed for an additional year. New fellows at Cal Tech are Andrew Guttman, Brooklyn, N. Y.; Daniel B. Olfe, Homewood, Ill.; Eli Reshotko, Cleveland, Ohio; and Donald L. Turcotte, Bellingham, Wash. Gunnar E. Broman, of Sweden, now living in Altadena, Calif., was reappointed.

Appointees at Columbia are Harvey M. Berkowitz, Brooklyn, N. Y., and Anthony E. Le Cara, Farmingdale, N. Y. Fellows appointed for another year are Leonard C. Lidstrom, Glen Ullen, N. D., and John M. McCormick, Philadelphia, Pa.

Missiles Seen Taking Big Slice of Electronic Sales

Over-all 1957 military electronic volume will rise this year to $3.5 billion, compared with $2.8 billion in 1956, with missiles making up the largest slice of the pie, James D. Secrest, executive vice-president of the Electronic Industries Assn., estimated last month.

Secrest noted that the present shift from aircraft to missiles in military planning would curtail aircraft electronic orders somewhat.

Electronic Equipment Survives 5-Mile Supersonic Plunge

The crushing impact of 1000 g couldn't dent a tiny, transistorized sun position indicator, recovered, still intact and operating under 12 ft of sand, after a 5-mile supersonic test dive in a Lockheed X-17 re-entry test missile over the California desert.

The sun indicator, developed by Nicholas K. Marshall, Lockheed Aircraft Corp. scientist, has an electronic eye which "sees" the sun flash by during rotation of the missile. Telemetering equipment translates each look into roll-rate and pitch-and-yaw information.

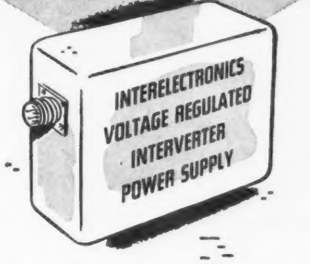
The experiment, conducted at Holloman Air Development Center, was designed to determine how much shock, temperature and pressure sensitive missile instruments can take.

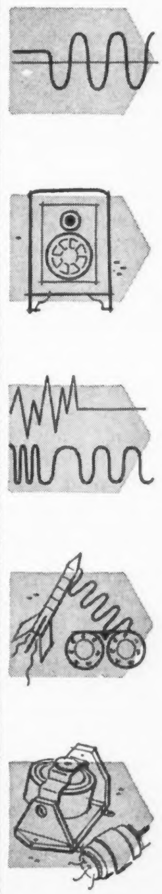
New Standards Lab

International Telephone and Telegraph Corp. last month dedicated its new standards laboratory. Designed to supplement and extend the work of the National Bureau of Standards, the privately owned facility will be available, says IT&T, to industry, universities, government and scientific foundations.

NEW!

DC to DC and DC to AC solid-state power converters voltage regulated, frequency controlled, for missiles, telemetering, gyros, servos





Interelectronics Interverter solid-state thyratron-like elements and magnetic components convert DC to any number of voltage regulated or controlled frequency AC or filtered DC outputs from 1 to 1800 watts. Light weight, compact, 90% or better conversion efficiency.

Ultra-reliable in operation, no moving parts, unharmed by shorting output or reversing input polarity. Complies with MIL specs for shock, acceleration, vibration, temperature, RF noise.

Now in use in major missiles, powering telemetering transmitters, radar beacons, electronic equipment. Single and polyphase AC output units now power airborne and marine missile gyros, synchros, servos, magnetic amplifiers.

Interelectronics — first and most experienced in the DC input solid-state power supply field, produces its own solid-state gating elements, all magnetic components, has the most complete facilities and know-how—has designed and delivered more working KVA than any other firm!

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Environmental Engineers Hold First Technical Meeting

Chicago was host to the first annual technical meeting of the Institute of Environmental Engineers during a recent two-day session. An equipment conference of the Environmental Equipment Institute was held concurrently with the meeting.

The program included the presentation of 18 technical papers, displays of environmental test equipment and field trips to the Basic Research Laboratory at the University of Chicago.

The IEE and the EEI are associated national engineering societies devoted to the advancement of the science of environmental simulation and testing. Henry F. Sander is provisional president of the IEE and Charles E. Earl is president of the EEI. George D. Wilkinson is general manager of both groups.

Among the technical papers presented, several are of particular interest to the propulsion and missile industries. For example, a paper on "Environmental Testing with Random Noise Vibration," by D. G. Douglas, Rocketdyne, told of laboratory tests of rocket engine components subjected to random noise vibration and detailed a procedure whereby the operational response of nonlinear elements to vibration may be determined.

P. H. Brandt, of Murphy & Miller, Inc., gave a paper on "High Altitude Missile Guidance Equipment Tested on the Ground," in which the problems of simulation of 120,000 ft altitude and −110 F temperature are discussed. "Ram Air Simulation During Temperature-Altitude Tests," by Neal A. Cook, Westinghouse Air Arm Div., indicated the difficulty of performing temperature-altitude tests on nonpressurized electronic equipment while maintaining internal cooling. Means of calibrating vibration transducers at temperatures up to 1000 F were discussed by W. R. Elliot, Boeing Aircraft Corp., in his paper on "High Temperature Vibration Measurements." "Predicting and Evaluating Low Frequency Vibration Environments of Aircraft," was the title of a paper by E. J. Kirchman, The Martin Co., in which equipment design, isolator requirements and environmental testing techniques were evaluated with respect to low-frequency aircraft structure vibration.

Alternatives to complete simulation in the case of large equipment were suggested by R. M. Mains, Knolls Atomic Power Laboratory, in his talk on, "What to Do When It's Too Big to Test." Problems in humidity instrumentation and control were the topics of two papers—"Problems of Humidity Instrumentation," by J. Boyle, Boyle Engineering Laboratory, and "Design Consideration for Advance Performance Temperature, Humidity, and Altitude Parameters in a Test Facility," by B. Friedman, Tenney Engineering, Inc.

The effects of acoustic environment on structures and electronic equipment were discussed by E. H. Stepp, Convair; H. H. Hubbard, NACA; and I. Dyer and J. Baruch, Bolt, Beranek & Newman, Inc.

Papers presented at the technical sessions will be published shortly and will be distributed through the IEE.

R. W. Ziemer
Armour Research Foundation

Virtually Automatic Control Systems for B-58 Hustler

Virtually automatic control systems will direct the flight path of the Convair B-58 Hustler and assure accurate release of its throwaway missile pods. The controls automatically supply continuous information for guiding the supersonic bomber to and from its target and releasing the pods.

Convair has announced that follow-on production of the ship's primary navigation and guidance systems has been assigned to Sperry Gyroscope Co., where a special Sperry-Convair engineering team developed the systems.

Bell Labs Develops Miniature Computer

Bell Laboratories has developed an experimental digital computer which takes up little more space than a TV set and operates on even less electricity. Called the Leprechaun, the computer, developed for the Air Force, was made possible through the extensive use of transistors. The computer's great flexibility, it is claimed, will allow it to be used as a test model for research on digital computers for military applications, since proposed designs can be lab-tested through the Leprechaun without the need for construction of new equipment.

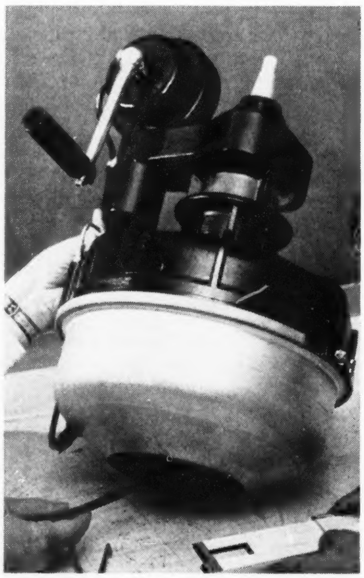
Navy Curtails Programs For Two New Planes

The Navy, in a move to cut spending, has curtailed programs for the development and procurement of two new aircraft under contracts already awarded to Douglas Aircraft Co. and Lockheed Aircraft Corp.

The Douglas contract called for production of four test models of the A4D-3, described as a "more versatile version" of the A4D-2, a midget jet bomber of nuclear capability currently in production. This program has been terminated. Size of the contract was not disclosed.

The contract with Lockheed, totaling \$6.9 million and calling for the construction of a new-type radar picket plane topped by a large radar dome, has been more than half eliminated. Development will continue through to the construction of a mock-up, but no further.

Lifts More than Its Weight



Solar Aircraft Co. engineers check mock-up of firm's new YT-62 gas turbine. Weighing but 50 lb, it reportedly produces 55 shaft hp plus 12 lb of thrust, and will be used in one-man helicopter.

AF Pilots Train on Vertijet

Two AF pilots from Edwards AFB who will eventually fly the Ryan X-13 Vertijet have started their familiarization course with the plane by operating its immediate ancestor, the tethered test vehicle on which Ryan developed the principles of vertical flight. Later, they will go through checkout with the X-13 itself at Edwards.

new equipment and processes

EQUIPMENT

Liquid Level Sensor: A liquid level sensor for aircraft, missile fuel and oxidizer systems, and propellant control has been announced. Model RC-1A sensor operates on ultrasonic principles to detect the presence or absence of liquid at a predetermined level, has high sensitivity and virtually instantaneous response, and operates at temperatures from −200 to 125 C. Acousta Associates, Inc., Glenwood Landing, L. I., N. Y.

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Rotary Selector Switch: Current uses of the Janco 1211 switch include missile ground checkout systems and other electrical applications. Built to have a life of over 10,000 double cycles, the 16-position switch can be modified to have one to eight wafers and two to 16 contacts per wafer. Janco Corp., 3111 Winona Ave., Burbank, Calif.

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Hydraulic Power Package: For use in guided missiles and supersonic aircraft, a new motor-driven hydraulic power package has an envelope incorporating an electric motor, hydraulic pump, valves and reservoir. The units permit wide latitude in systems design because of their power, small size, compactness and light weight. Adel Precision Products Div., General Metals Corp., Burbank, Calif.

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Subminiature Timer: Lighter than commercially available motor-driven timing devices is a subminiature timer designed for 155 v 400 cycles, 115 v 60 cycles and 28 v dc. Airborne electronic systems, missiles, rocket-launching mechanisms, and other military and industrial applications represent potential uses for repeat cycle, time delay and sequence control. Advanced Products Co., 59 Broadway, North Haven, Conn.

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Sun Battery: An 18 by 18 in. sun battery has been developed to convert solar energy to electrical current for a variety of applications. Initial cost of the battery, consisting of nine selenium cells, is 50% less per milliwatt of output than that of batteries using other semiconductor materials. International Rectifier Corp., 1521 E. Grand Ave., El Segundo, Calif.

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Position Transmitter: Model 851-75S-5 spiralpot shaft position transmitter has infinite resolution and a null point at the center of rotation. It consists of a standard three-turn, slide-wire spiralpot potentiometer with resistors wired in a bridge circuit. One leg of the bridge is shunted with the variable section, and output can be read on a sensitive light beam galvanometer. G. M. Giannini & Co., 918 E. Green St., Pasadena 1, Calif.

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Cable Connector: A subminiature snap-lock coaxial cable connector and mating receptacle is available in 50, 75 and 95 ohm sizes. The plug cannot be removed by pulling on the cable or by vibration, but only by sliding the knurled sleeve toward the cable end. Automation-Engineering Corp., 723 Sonora Ave., Glendale 1, Calif.

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Rate Gyro: Hermetically sealed in a dry helium-filled steel case, Model RG15-0102-1 rate gyro provides trouble-free damping, with choice of inductive or potentiometer pick-off. Available with regular AN or new pigmy connector. Humphrey, Inc., 2805 Canon St., San Diego 6, Calif.

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Pressure Pickup: Flange mounted Dynisco pressure transducers combine high output and small size with accurate measurement. The operating features make the unit suitable for missile, airplane, wind tunnel or other research where transducers of great accuracy are required. Output varies from 25 to 100 millivolts full scale, depending on pressure range. Dynamic Instrument Co., 28 Carleton St., Cambridge 42, Mass.

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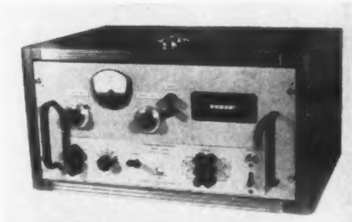
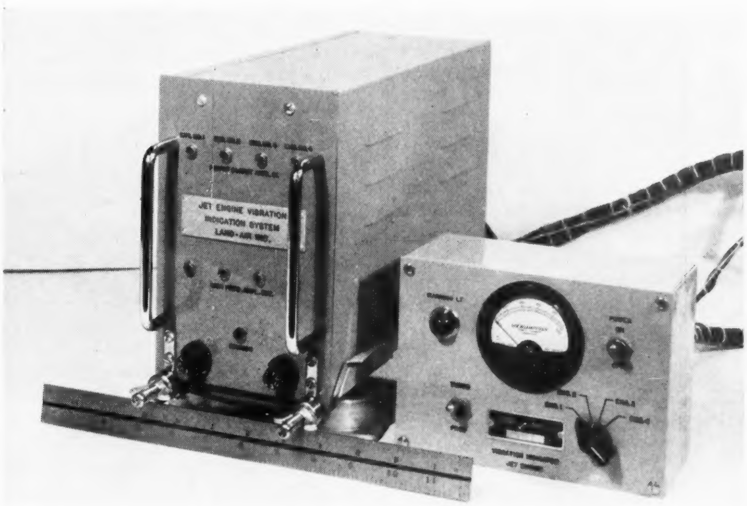
Noise Suppressor: To reduce the



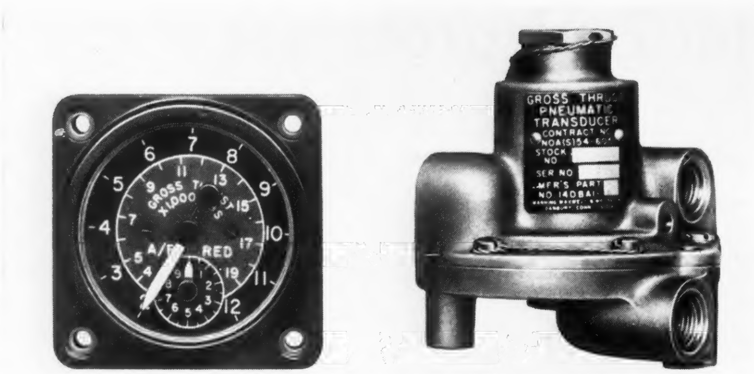
Adjustable Programmer Counter

Test apparatus in which limits are sensed by strain gages, thermocouples or any other transducers having a maximum output less than 100 millivolts dc, can be turned on and off by the Spar programmer counter. It operates on 110 v ac. A flashing light or ringing bell can be supplied to show when the counter is registering. Spar Engineering & Development, Inc., Wyncote, Pa.



Jet Engine Vibration Indicator

The Jevis (jet engine vibration indicator system) is applicable to turboprop, turbojet, and pure jet engine environments where vibration level is of prime importance. The Jevis is all-transistorized, weighs 8 to 10 lb, and requires only 6 to 12 watts. The system has an amplifier module and meter switching box. Land-Air, Inc., 7444 W. Wilson Ave., Chicago 31, Ill.



Thrust Indicating Instrument and Pneumatic Transducer

Pneumatic in operation, the Type 141LA1 gross thrust measuring system draws its power from compressor discharge pressure. The two components, one engine and one cockpit mounted, weigh a total of 1.5 lb. Thrust is represented on a 300-deg arc, 2-in. dial, and includes a multiturn vernier for interpolation between 1000-lb graduations. Manning, Maxwell & Moore, Inc., Aircraft Products Div., Danbury, Conn.

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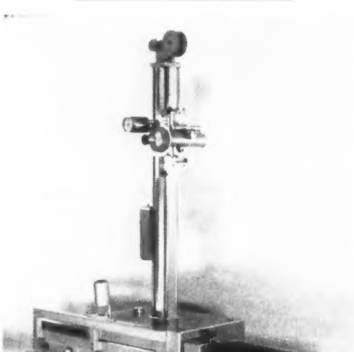
noise of jet engines operating on the ground, a portable muffler has been developed which uses a conelike framework with the base behind (but not necessarily connected to) the exhaust pipe. The cone is formed by steel hoops of decreasing diameters, set one behind the other. As the exhaust wake passes through this tapering row of hoops, it is broken up and dispersed into a relatively slow-moving mass. The Martin Co., Baltimore, Md.



Cathetometer for Measurements

Coordinate cathetometers, a new concept in measuring instruments, make both horizontal and vertical measurements in a vertical plane at one setting. Because the object being measured need not be rotated, inspection time is reduced. A microscope or telemicroscope mounted on a carriage is moved up or down on a vertical bar, and the assembly is moved left or right on horizontal ways. Gaertner Scientific Corp., 1201 Wrightwood Ave., Chicago 14, Ill.

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Hydraulic Filters: A line of six high pressure, high temperature hydraulic filters with stainless steel wire mesh filter elements has been developed for aircraft use. Ranging in nominal capacity from 1.2 gpm and adaptable to various port tube sizes, the filter can be made up with or without relief valves. Purolator Products, Inc., Rahway, N. J.

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Laboratory Furnace: A research laboratory furnace for vacuum melting of metals that require controlled atmosphere melting is now on the market. It produces the standard deep evaluation button by arc melting of sponge or shavings, and sample ingots from 2 to 6 in. diam in lengths up to 16 in. by the consumable electrode melting process. Oregon Metallurgical Corp., P. O. Box 311, Albany, Ore.

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Shut-Off Valve: Free of dependence on moving seals, the MV-126B miniature solenoid shut-off valve is already in use in fuel starter systems. This unit is operated by a 24 v d-c, 1 amp power supply at pressures from 0 to 500 psi, and temperatures from −65 to 350 F. Marotta Valve Corp., 330-17 Boonton Ave., Boonton, N. J.

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Stressed-Panel Fastener: The Waldes QAF is a quick-action stressed-panel fastener that will withstand high shear and tensile loads, lock positively in less than one-half torque-free turn, and compensate for sheet separation resulting from warpage in panels. The device is for use on structural load-carrying panels in aircraft, guided missiles and other applications. Waldes Kohinoor, Inc., 47-16 Austel Pl., Long Island City 1, N. Y.

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MATERIALS

Insulator: Polyfoam, a strong and durable new foam product for use as a cushioning material and sound and thermal insulator, may revolutionize the rubber and plastic foam industries. In development for more than two years, the material, a polyether-based urethane foam, is now in volume production. The General Tire & Rubber Co., Akron, Ohio.

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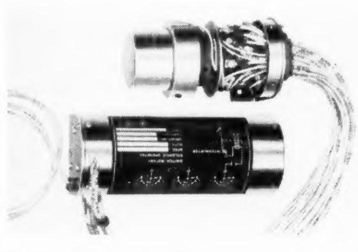
Stainless Steel Sheet: Costing about 50% less than solid stainless, a new Chromalloy stainless steel sheet withstands operating temperatures up to 1500 F. The Chromalloy process involves the diffusion of chromium into the surface of steel where an iron and chromium atom exchange occurs, forming a stainless surface integral with the base metal. Chromalloy Corp., 450 Tarrytown Rd., White Plains, N. Y.

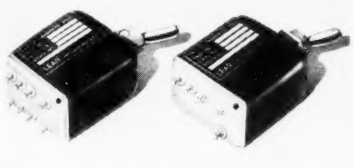
•

Reinforced Seals: Fuel resistant, fabric-covered and fabric-reinforced seals for −65 to 400 F applications, use LS-53, Dow Corning's new fluorosilicone rubber. The seals provide high tear and abrasion resistance. The rubber remains resilient, resists swelling and destruction by fuels and oils. Connecticut Hard Rubber Co., 407 East St., New Haven 9, Conn.



Power Programmer

A compact power programmer controls 24 separate circuits and programs a sequence of operations with high reliability. For direct actuation of power devices, the unit eliminates the need for relays and interlocking circuits. There is no detectable contact opening or bounce at 40 g shock loading, or vibration of 50 to 500 cps at 0.036 double amplitude. Mason Electric Corp., 3839 Verdugo Rd., Los Angeles, Calif.



Magnetically-Held Switches

An automatic-disconnect switch, magnetically held and automatically disarmed when the energizing voltage drops between 13 and 5 volts, also has a fail-safe feature assuring that the solenoid will not pull the switch closed. The unit will withstand vibration frequencies up to 500 cps at 10 g loads. Lear, Inc., 110 Iona Ave., N. W., Grand Rapids, Mich.

Strain Gage: High temperature strain gages for measurements up to 1100 F are offered in standard, rosette or cross types. The strain sensitive element is Karma wire, the nominal resistance 120 ohms, and the gage factor 2.25. Columbia Research Laboratories, Woodlyn, Pa.

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Flow Measurement: An inexpensive electronic liquid and gaseous flow measuring system measures the flow through an orifice plate by means of electrical signals. The signals are proportional to the flow rate and accumulated flow. An adapter adjusts the calibration to suit the measurement problem. Computers, Inc., 2025 Harold St., Houston 6, Texas.

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Compression Tester: Model TP-121 is a portable, hydraulically operated machine for quick, accurate compression testing. The unit combines simple hand pump operation with ease of adjustment in vertical dimension, and a capacity of 150,000 lb. Steel City Testing Machines, Inc., 8817 Lyndon Ave., Detroit 38, Mich.

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Testing Cabinet: Available for all types of environmental testing, the Universal cabinet is suitable for tests at temperatures from −120 to 300 F, and can be arranged for altitude tests and variable humidity control. Hudson Bay Co. Div. of Labline, Inc., 3070-82 W. Grand Ave., Chicago 22, Ill.

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Oil-Free Gas Source: For missile and test applications where gas cleanliness is most important, an oil-free gas booster compressor serves as a source of high pressure, dry, uncontaminated helium or nitrogen. Using commercial gas bottles, the compressor operates without lubrication. Outlet gas pressures are from 6000 to 10,000 psi, with average capacities from 10 to 20 scfm using inlet pressure sources between 500 and 2200 psi. Haskel Engineering & Supply Co., Glendale, Calif.

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Internal Inspection: The Lenox borescope is used for complete internal inspection of tanks, vessels, combustion chambers and other equipment. An adjustable mirror, controlled by a hand wheel, permits scanning from retrospective through right angle to forward oblique. Magnification 10 power; field of vision 9 in. diam at 24 in. Lenox Instrument Co., 2010 Chancellor St., Philadelphia 3, Pa.

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Flow Test Facility: To simulate in-flight and ground refueling operations of high-flow fuel systems, a newly completed facility will pump up to 1800 gpm at 75 psig. Present refueling methods have systems capable of handling flows up to 600 gpm, and some aircraft now being designed will accept fuel in the area of 1200 gpm. Parker Aircraft Co., 5827 West Century Blvd., Los Angeles 45, Calif.

Sinus Vibrometer: Developed in Sweden, a self-contained vibrometer utilizes the energy of the vibrating body as its only power source, and has no batteries or electronic connections. The amplitude is read directly on a scale. Intended for measurement of absolute vibrations, the pickup is of the seismic type. Eric Wahlquist Business Engineering, 1827 Norman Ave., Park Ridge, Ill.

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PROCESSES

Titanium Seasoning: For seasoning titanium specimens, Riehle creep testers are furnished to customers' specifications. The process incorporates the use of electric furnaces arranged in tandem so three specimens can be treated at one time. Riehle Testing Machines Div. of American Machine and Metals, Inc., East Moline, Ill.

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Template Reproduction: Built for Convair, one of the largest cameras in the world is used to reproduce templates. With this photomechanical process, templates up to 5 by 12 ft, accurate within 0.002 in. can be made by projecting the image of a drawing onto a sensitized metal plate,

Cryogenic Specialists

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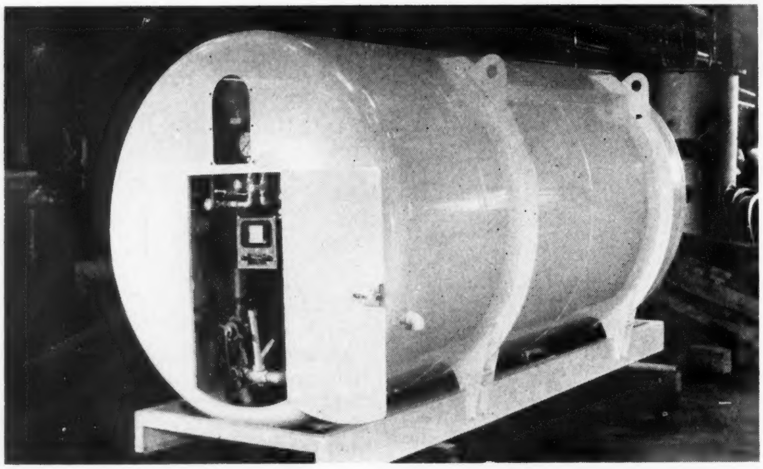

Lox and Nitrogen Storage Unit

Low-loss storage units for liquid oxygen and nitrogen are available in capacities of 50 to 3500 gal, and up to 10,000 gal from bulk storage. Standard equipment includes bottom fill and discharge line, top fill line, liquid level gage, vacuum valve and filters, thermocouple vacuum gage, pressure gage, quick pressure build-up system and extended valves on liquid lines. Hofman Laboratories, Newark, N. J.

then machining or cutting the resultant pattern. Robertson Photo-Mechanix, Inc., 7440 W. Lawrence Ave., Chicago 31, Ill.

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PRODUCT LITERATURE

Conversion Tables. A series of tables, simplifying conversion from decimal to binary numbers, and vice versa, has been prepared for distribution. Barnes Engineering Co., 30 Commerce Rd., Stamford, Conn.

Ryers Balances. Two balances, the Progress for analytical laboratory weighing to 0.00001 of capacity, and the Rapid for bulk weighing and dispensing to 1 kg capacity, are described in a two-page data sheet. Arthur S. LaPine & Co., 6001 S. Knox Ave., Chicago 29, Ill.

Dynamotor. Bulletin 15F5 is a data sheet on a 1-lb dynamotor for use in guided missiles, featuring 100-hour brush life at 50,000-ft altitude and 500 hours at sea level. Motors operate in ambient temperature range of from −40 to 71 C standard, with special units available for operation up to 100 C ambient. Induction Motors Corp., 570 Main St., Westbury, N. Y.

Ultrasonic Testing. Two bulletins on ultrasonic testing are available. They discuss the uses of Vidigage, an ultrasonic resonance instrument for detection of corrosion and laminar flaws, and measurement of thicknesses of metal or plastic. Corrosion inspection is described in Bulletin V-301 and flaw detection in Bulletin V-302. Branson Instruments, Inc., 40 Brown House Rd., Stamford, Conn.

Hydraulic Components. A 16-page listing contains product information and engineering data on hydraulic pumps, fluid motors, aircraft-type pumps and servo systems. Eastern Industries, Inc., 100 Skiff St., Hamden, Conn.

Engineering Services. A booklet describes facilities of a team of engineers and scientists formed to provide consulting and development services to the missile industry. The team has engaged in rocket vehicle programs, and basic research in aerodynamics and upper atmosphere physics. Era Engineering, Inc., 1009 Montana Ave., Santa Monica, Calif.

Quick Release Pins. Engineering data are contained in a brochure on single-acting self-locking quick-release pins. It contains information on materials, finishes, head styles, dimensions and load factors. Diagrams give positive callout procedures, arranged in an easy-to-use manner. Aviation Developments, Inc., P. O. Box 391, Burbank, Calif.

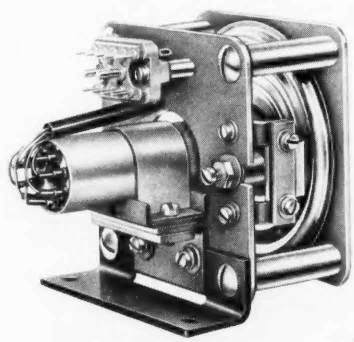
Corrosion Tester. A means for determining rates of corrosion by use of Corro-Dex is described in a 16-page booklet. Corro-Dex is available in two models, one line-operated and one portable battery-operated. Probes of steel, nickel, monel, copper, brass, aluminum, lead, etc., are available. Labline, Inc., 3070–82 W. Grand Ave., Chicago 22, Ill.

Filtration. Folder No. 54-100 is devoted to filters designed for aircraft and missiles. These micro-magnetic filters trap submicronic ferrous particles by magnetic action, providing mechanical filtration of 10 microns or finer. Cuno Engineering, Meriden, Conn.

Turbine Flow Meter. A meter for precise measurement of liquid flow is described in a new catalog. The turbine flow meter, inserted into process piping, measures the rate of flow of a variety of liquids having flows of from less than 1 to more than 2500 gpm. Fisher & Porter Co., 75 Jacksonville Rd., Hatboro, Pa.

Servomotor-Rate Generator. Data sheet 872 gives details of the Model 11 MG 460/460 servomotor-rate generator. Data includes specifications, characteristics, three-view drawing and a cut-away schematic. Helipot Technical Information Service, Newport Beach, Calif.

Magnetic Tape. The effects of heat, humidity and tension on magnetic tape are discussed in Sound Talk Bulletin 35. Titled "Physical Limitations of Magnetic Tape," it is illustrated with graphs which show stress characteristics of the different types of Scotch magnetic tape. Minnesota Mining and Mfg. Co., 900 Bush St., St. Paul 6, Minn.



Data System Pressure Transducer

Developed for use in data reduction systems, a new pressure transducer converts a 3 to 15 psi signal to a-c millivolts directly proportional to the pneumatic output. When pressure is applied to the sensing element, the resulting movement of an expandable capsule displaces an armature which induces opposing voltages in twin secondary coils. This voltage is linearly proportional to the pressure input. Fischer & Porter Co., 93 Jacksonville Rd., Hatboro, Pa.

Computers. Remington Rand Univac has a bibliography of computer literature, Booklet EL 335, believed to be the first of its kind, and prepared with emphasis on scientific and engineering use of computers. Remington Rand Div. of Sperry Rand Corp., 314 Fourth Ave., New York 10, N. Y.

Resistors. Molded composition resistors 0.067 in. diam and 0.140 in. long are the subject of Bulletin 150. Expanding the line of $^1/_2$, 1 and 2 watt resistors, these subminiature units are rated at $^1/_{10}$ watt. Ohmite Mfg. Co., 3650 Howard St., Skokie, Ill.

Equivalents Chart. A three-color wall chart of decimal equivalents, especially designed for easy readability, is arranged in two columns to allow ample space for large size ($^5/_{16}$ in. high) numerals. Decimals run down the center of each column, and guide lines join each decimal with its equivalent fraction. Sales Dept., John Hassall, Inc., Westbury, L. I.

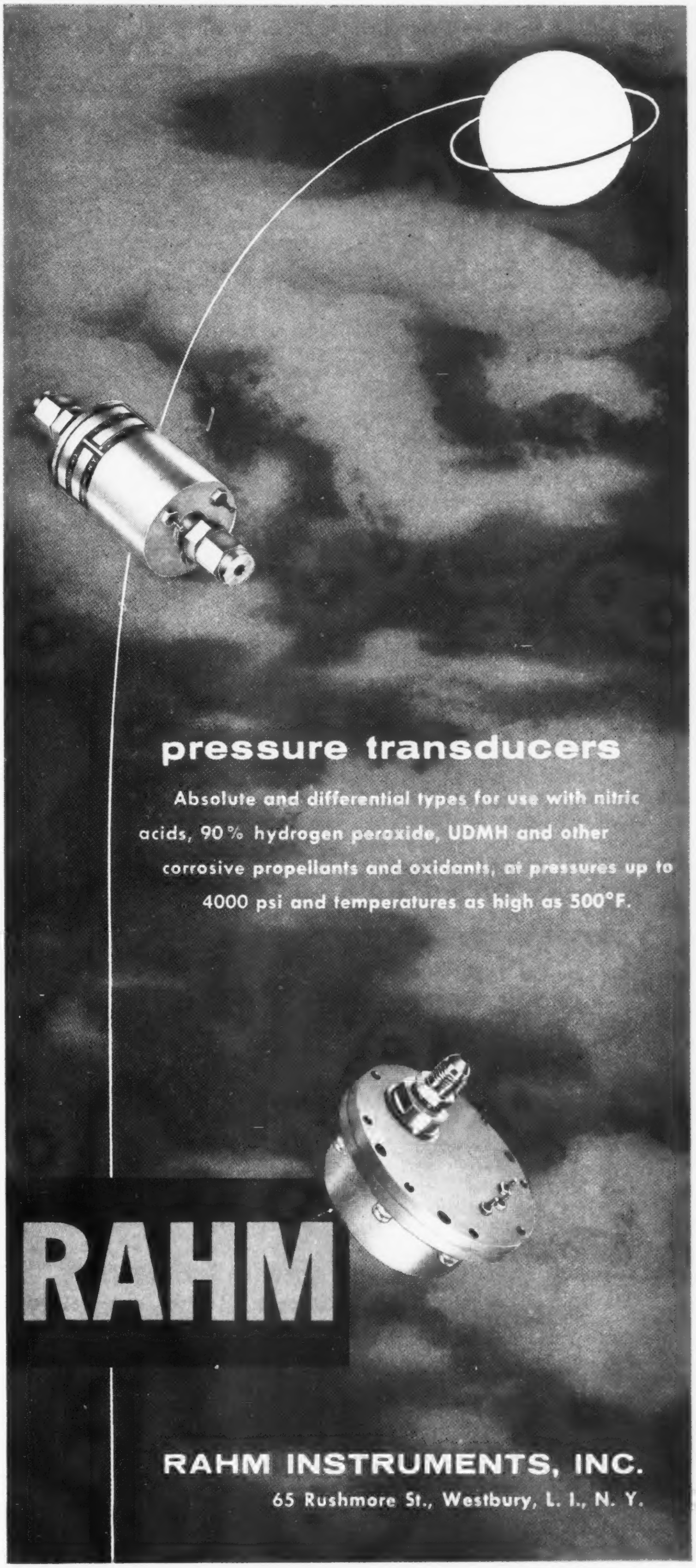
Organization Improvement. A booklet on improving the organization and management of engineering and R&D departments is the result of a report based on specialized experience. Wallace Clark & Co., Inc., 521 Fifth Ave., New York 17, N. Y.

Acceleration Testing. Four models of g-accelerators or centrifuges used to subject aircraft and guided missile components to simulated operational g-loadings are presented in an illustrated catalog. Genisco, Inc., 2223 Federal Ave., Los Angeles 64, Calif.

Electronic Instruments. A designers' guide with drawings, description, theory of operation, mounting details and specifications on the Trio line of miniature, panel-mounting instruments is available. Technical Promotion Mgr., Trio Laboratories, Inc., 4025 Merrick Rd., Seaford, N. Y.

Lubricants. Bulletin 110 contains extensive technical data on lubricants. Illustrated with charts, diagrams, graphs, tables and photographs, it supplies scientific information on lubricating problems and their solution. Alpha Molycote Corp., 65 Harvard Ave., Stamford, Conn.

Hydraulic Components. Pumps and motors, motorpumps and hydraulic packages miniaturized especially for missiles are described in Bulletin No. A-5216. Two series of constant displacement piston-type pumps are shown. Miniature vane-type pumps for missile use are also described. Vickers, Inc., Aero Hydraulics Div., P. O. Box 302, Detroit 32, Mich.



Missiles Mean Business

(CONTINUED FROM PAGE 33)

Army is planning to cut back procurement of Nike-Ajax weapons by $90 million to make way for the newer Nike-Hercules. The Army also plans to evaluate the Navy's Talos and see how it measures up against its own Nike-Hercules.

Procurement of Honest John and Corporal missiles will also trail off as the Redstone, Little John and Sergeant find their way into operational units. Dart and Lacrosse are also good bets to get continuing Army financial support this year. Possible purchases of Nike-Ajax, Honest John and Corporal missiles (with foreign aid funds, not defense money) for use by certain NATO nations could offset the decline in domestic demand for these weapons.

The only service to get more money this year for both missile procurement and R&D, the Navy, has been shuffling its funding like a Las Vegas card dealer.

With a good chance that the Air Force will buy in on the Sidewinder, the Navy has decreased its own production requirements for the missile by about $5 million. At the same time, it has upped the improvement program for the missile by a corresponding amount, thus keeping overall Sidewinder spending close to the 1957 level, or about $38 million.

The Navy also plans to continue development of the Bullpup, another weapon that will probably find operational use with both the Navy and Air Force.

Petrel Phased Out

The Petrel has been phased out of production. The Talos program has already been cut back $9 million to $44 million for fiscal 1958 and may be further reduced. Meanwhile, the Navy has tentatively allotted $32 million to the Tartar project, up $19 million over 1957. Terrier procurement is up $7 million, while supporting costs (for improvement of the missile) are down $4.6 million. The total Terrier program now stands tentatively at $59 million.

Another large jump in missile procurement contemplated by the Navy is for its ballistic missile program—from $2.6 million last year to $15.7 million for fiscal 1958. In addition, the Navy has requested $68 million in research and development funds for continuation of R&D work on the Polaris.

The Bureau of Ships has asked that its R&D allotment for guided missiles and related equipment be raised from last year's $40,000 to $870,000. The increase is slated to go into development of control equipment for the Regulus and Triton. The Bureau of Ordnance has also tentatively scheduled a $2.6 million increase in R&D for the Triton, as well as a $1.2 million R&D increase for Tartar. At the same time, it is decreasing support of Terrier by $2 million, Talos by $1.5 million and Sidewinder by $500,000.

In the nonweapon field, the Office of Naval Research has subtracted $15 million in Vanguard support from its proposed 1958 R&D budget. But President Eisenhower has asked Congress for $34.2 million under miscellaneous supplemental appropriations for the earth satellite project.

Optimism Is Guarded

At first glance, it looks like a good year for the missile makers. But, as a result of the Navaho cancellation and statements by top DOD officials that further cutbacks in other major projects can be expected, many missile men have become somewhat guarded in their optimism.

To hold spending down as directed, these men point out, the military will undoubtedly have to be more selective in its weapon programs. It will probably have to make a choice between such systems as the Atlas and Titan, Talos and Nike-Hercules, Thor and Jupiter, Falcon and Sidewinder, and so on. It is very unlikely, they feel, that the services will be able to keep alternate systems under development as now. And, when the choices are made, they will echo throughout the industry.

Thus, while the government plans to spend more money on missiles this year than ever before, most of it is already earmarked for such top priority items as ballistic missiles and defenses against them. And the feeling in industry is that the new government attitude may actually foreshadow a tightening-up of defense spending for missiles, regardless of an initial impression to the contrary.

Army's Redstone Missile Reported Launched in Florida

A short-range Army Redstone rocket was reportedly fired recently in a test at Cape Canaveral, Fla., AF missile test center, according to witnesses who saw a white glow over the area for about five minutes after the launching.

The missile shot straight up, leveled off and headed out over the Atlantic Ocean on the tracking range, observers reported.

Flight of the Hawk

Army's new Hawk surface-to-air missile clears launcher on its flight to stalk attacking aircraft. Sixteen ft long and 14 in. in diam, the Hawk can be used either at fixed installations or by fast-moving combat troops.

Sperry Rand Expands Lab

Sperry Rand Corp. will add a 100,000 sq ft unit to its research and development laboratory at Salt Lake City, Utah. The addition, completely air-conditioned, will include a 90,000 sq ft manufacturing area, a 5000 sq ft environmental test area and a 5000 sq ft utility area.

Army Tests Solar Cells For Satellite Instruments

Army Signal Corps scientists from Fort Monmouth, N. J., were out to prove that solar batteries could be the ideal power source for satellite instrumentation. To make the test, they attached glass-protected clusters of solar cells to the skin of an Aerobee-Hi launched by the Navy at White Sands Proving Ground, N. Mex.

Results: At an altitude of 190 miles, approximating satellite conditions, the batteries functioned perfectly; the cells provided continuous electrical output from the time of firing until the rocket's radio ceased functioning on re-entering dense atmosphere; and there were no major voltage fluctuations.

Conclusions: Solar cells attached to the skin of the earth satellite would supply instrument power during about 60 of each 100 min, and power would be sufficient to relay information back to Minitrack stations on earth.

Military Aides Briefed on Vertijet

Three of President Eisenhower's top military advisers have been given a briefing on the performance and tactical potential of the Ryan X-13 Vertijet, world's first pure jet vertical take-off and landing plane. Attending the White House conference were: Capt. E. P. Aurand, Naval Aide to the President; Lt. Gen. E. R. Quesada, USAF Ret., special assistant to the President for Aviation Facilities Planning; and Brig. Gen. Andrew J. Goodpaster, staff secretary to the President.

After public flight demonstrations at Andrews AFB as a feature of the USAF Golden Anniversary Air Show, the X-13 was flown to and from the pavement beside the Defense Department building at the Pentagon.

Western Electric Sends Missile Men Back to School

Twenty missile engineers from Western Electric Co. are back in school again as they attend courses set up by the company as part of its new program of graduate education for engineers.

The program, established in cooperation with a number of universities, is being carried out on university campuses as well as at three specially equipped centers in New York, Chicago and Winston-Salem, N. C. Missile men are attending the Winston-Salem center.

Six universities—New York University, Northwestern, Illinois Institute of Technology, Cornell, Duke and North Carolina State—are currently cooperating in the program. The list is expected to expand as the program develops. The company pays all costs.

Newly employed engineers will be given full-time engineering assignments for a few months and then attend a nine-week course designed to introduce them to Western Electric engineering concepts. Upon completion of the course, they will return to their jobs for six to 12 months, when they become eligible for "general development" courses. Subsequently, they, as well as other experienced engineers, become eligible for "advanced development" courses.

This part of the program will consist of a series of courses offered singly or in pairs, each involving about 80 hours of study in particular areas, such as operations research, engineering statistics, computer theory, etc.

JATO Aids C-130 Transport Take-off

JATO has lifted the Lockheed Hercules C-130 medium transport off the ground in less than 150 yards take-off distance. Firing JATO bottles, the propjet troop-and-cargo carrier of the U. S. Air Force has cut its own short take-off distance in half.

In a series of JATO tests, the C-130, weighing more than 80,000 lb, was airborne in between 400 and 500 ft. Only 4 sec were required to get the transport airborne. The C-130 was traveling at 50 knots, its brakes just released, when the eight JATO bottles were fired. The C-130 left the ground at an airspeed of 70 knots, and was traveling at 100 knots when it finished its climb. The bottles burned for 12 to 14 sec. JATO gave the C-130, equipped with four Allison T56 propjet engines, lifting power equivalent to an additional engine.

Boeing Jet Airliner

Artist's drawing of Boeing 717 jet airliner, third member of the Boeing family of commercial jet aircraft. The 717 will be ready for delivery in 1960 to operate on flights from 200 to 1700 miles, cruising at 550 to 600 mph at 25,000 to 40,000 ft.

J-75 Jet Engine Ingests Foreign Objects in Test

The commercial version of Pratt & Whitney's J-75 jet engine, the JT-4, has operated under an intensive simulated airline schedule during the past year in preparation for use on most American-made jet transports now on order. The twin-spool JT-4 and the JT-3 (civil version of the J-57) were put through a grueling series of tests last spring before their commercial certification by the CAA.

Problems of accidental ingestion of foreign objects have been intensified because of the open inlets on jet engines. Before receiving CAA approval, the two jets had to demonstrate an ability to absorb such items as lunch pails, rocks, wrenches, hats, jackets, several varieties of fowl and other assorted items without causing serious damage. To prove that the engines could swallow ice without damage, 2-in ice balls were fired from a specially constructed cannon into the engines' compressor at speeds up to 600 mph, thus simulating a severe hail storm.

Labor Dept. Launches Survey Of Nation's Research Resources

The U. S. Bureau of Labor Statistics has undertaken a survey for the National Science Foundation that will provide up-to-date information on research personnel and spending for research in all industries. Individual firms will not be identified and company data will be held in strict confidence.

British to Offer Jet Trainer on Export Market

Hunting Percival Aircraft and de Havilland Aircraft Co. will collaborate in the introduction of the Jet Provost Trainer for export purposes. Powered by the Armstrong Siddeley Viper engine, the Provost provides initial flight training with jet propulsion, and also covers the comprehensive intermediate training syllabus.

NSF Publications Available

Scientists who want to avail themselves of National Science Foundation publications may do so by requesting a list of available publications from the Publications Office, National Science Foundation, Washington 25, D. C.

Slow Fighter Output, Air Force Orders

In an obvious economizing mood, the Air Force has ordered producers of four of its most important supersonic fighter planes to slow down production.

Affected by the order are the F-101 day and all-weather fighters produced by McDonnell Aircraft Co.; the F-104 jet fighter produced by Lockheed; and the F-106 all-weather interceptor made by Convair. An AF spokesman indicated that the slowdown means it will take an additional year to complete present contracts for the aircraft.

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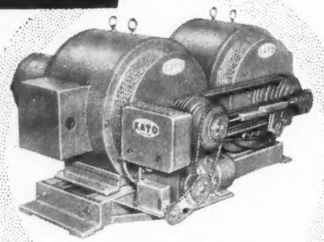

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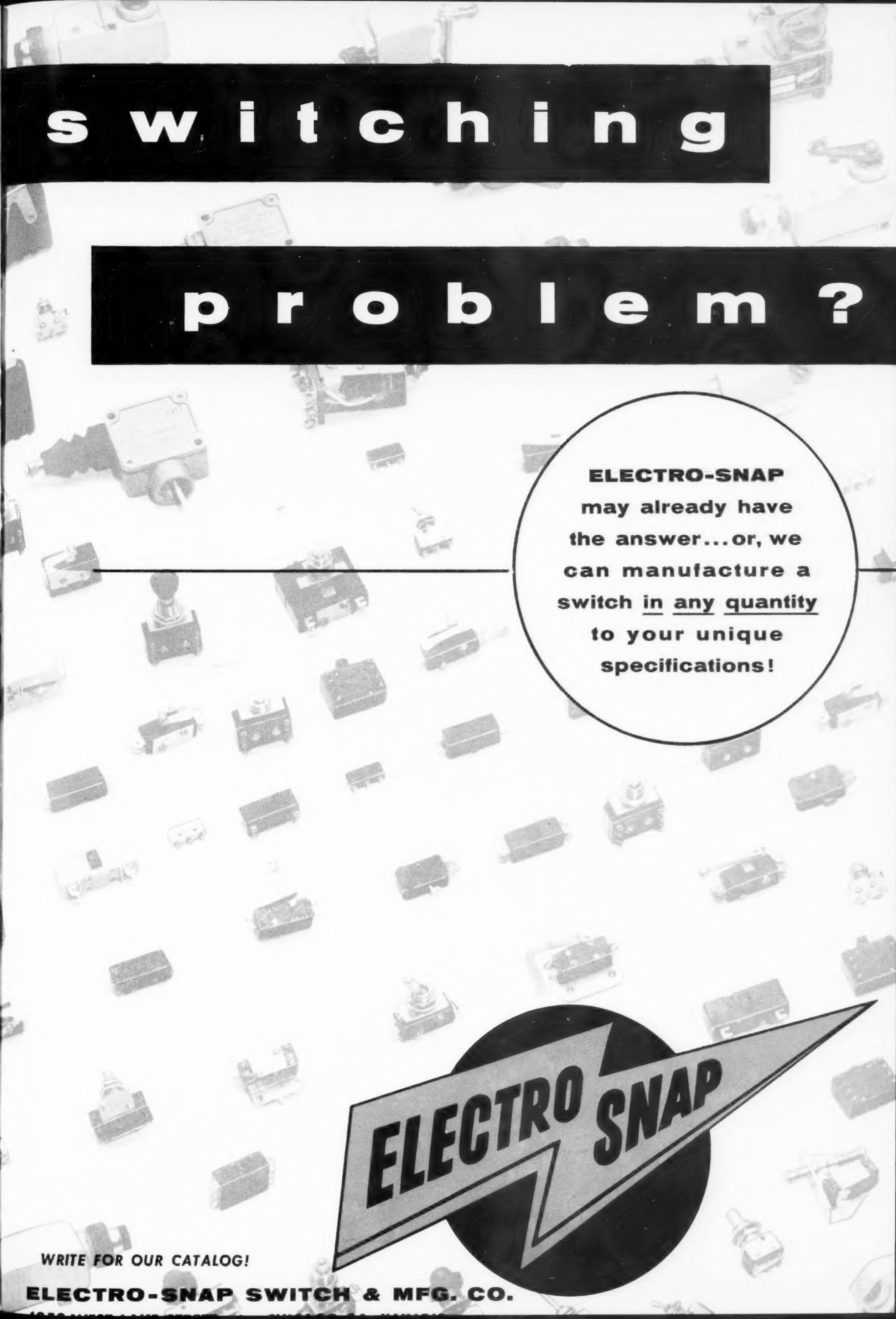
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